Interview with
Alfred S. Harrison

Education

Q: Let me start out by asking you if you would tell me about your youth and your education through high school.

A: Well, I grew up in Los Angeles and went to Los Angeles High School, and then the war came along. The war was going on when I graduated from high school, and then I was accepted into the U.S. Navy V-12 Program. Do you know what that is?

Q: Yes, I do. It was a wartime officer procurement program that paid your college expenses.

A: I was sent to the University of Southern California (USC), which was maybe two miles, three miles, from where I lived in Los Angeles. Then, having to make a choice as to what my options were--my options were law, medicine, dental, theology, and three different kinds of engineering, I arrived at civil engineering as the major that I was going to pursue in college. I stayed there under the V-12 Program for one year. Then after a year, they transferred us over to the Naval ROTC, and I finished out my four academic years at USC and got my degree of Bachelor in Civil Engineering in 1947.

Q: What were the influences that made you decide to study civil engineering in college?

A: Well, my interest at that time was history. I was planning to be a history major when I was in high school. I won a couple of history contests and so forth. Of course, I'd always done well in science and in math. When I showed up and registered for school, I was oriented to the V-12 Program. I was essentially given a day or a few hours to decide what my major was going to be. History was not one of the options, so I thought about it.

I had a grandfather, whom I never had met because he died before I was born, who was a mining engineer, and supposedly a hydraulic engineer, which was a field of civil engineering. So more or less on the spur of just a few hours, I decided my major was going to be civil engineering.

Civil Engineering Curriculum

Q: What was the curriculum in civil engineering like at USC at that time?

A: It was the standard civil engineering curriculum with surveying, mechanics, dynamics, structures, and courses in sanitary engineering, industrial engineering, chemical engineering, and hydraulics. These, of course, were backed up by math, at that time through differential equations, physics, and chemistry.

Q: Was there any effort by the Navy to speed up the program or to line you up to go into their Civil Engineer Corps?

A: We went three semesters a year. USC was and still is on the semester system, and we went three semesters a year. We went during the summer. As a result I graduated in three years.

Q: So you started in '44 then.

A: I started in June,'44, and I graduated in June,'47.

Q: Who taught the hydraulics course then? That wasn't normal to have hydraulics courses, was it?

A: Yes, that was one of the regular courses on the civil engineering curriculum. It was a course called Hydraulics. First there was a course called Fluid Mechanics, and then there was a course called Hydraulics that followed it up and hit some of the more practical aspects of using the principles of fluid mechanics.

Q: Do you remember who the instructor was?

A: His name was Miles. I don't remember his first name.

Q: He was not one of the leading stars of hydraulics in the United States.

A: I don't think so. USC academically wasn't that prestigious in those days, at least in civil engineering. From what I know now, I know it was a good, adequate, basic civil engineering curriculum that prepared me well for whatever I had to do.

Graduate Study at the University of California at Berkeley

Q: When can you say that you began to be interested in a specific part of civil engineering?

A: When I took fluid mechanics and hydraulics, I was very interested in that. Then, when I graduated from USC and applied for a fellowship at Berkeley, one of the teaching assistantships, one of the areas I could go into, was advanced fluid mechanics and hydraulics.

At that time, a new professor there, who had just come over from Cal Tech [California Institute of Technology], was H.A. Einstein. I liked Einstein. The courses I took from him I enjoyed, and they turned me on so I got into the field of hydraulics and sedimentation. Berkeley at that time had a very strong hydraulics and fluid mechanics department with Joe Johnson, H.A. Einstein, and Morrough P. O'Brien. Morrough P. O'Brien was the Dean of Civil Engineering at that time. These were all people who were eminent in the hydraulics business.

Q: Right. O'Brien certainly was, and Einstein, also.

A: Yes, that's right. I also became quite interested in soil mechanics because we took courses from Krinine, and [Karl] Terzaghi came around one time and taught a course.

Q: Did you have much to do with O'Brien?

A: No, he was just the dean. I'd met him. He was sort of a god-like figure on high, although very friendly and accessible. I had a lot to do with Einstein, also Johnson.

Hans Albert Einstein

Q: Can we talk about both of them? Take Einstein first since you worked with him more closely.

A: Yes. Einstein was, you might say, my mentor. I was associated with him off and on for the rest of his life. He had become a consultant with the Corps of Engineers in Omaha, where I was working, so I saw him quite often during my early career with the Corps. While I was a student at Berkeley, I was invited up to his home. I was his first graduate student. He was my advisor for my laboratory research and for my thesis.

I worked for him. I did his computations for his research experiments and for some consulting engineering jobs that he had. I was very fond of him. He was a great teacher, one of the best lecturers I've heard. He was one of the famous hydraulic engineers of his era.

Q: Well, his specialty was sedimentation, wasn't it?

A: His specialty was sedimentation. As a matter of fact, he published the first publication that included a complete theory of transport of sediment in streams.

Q: Yes, because his name crops up all of the time in publications on hydraulic engineering.

A: I did the calculations that were in his Department of Agriculture publication with all of the illustrated examples. I did that kind of work for him, sort of as his helper, you might say.

Q: Well, when you're at the right hand of a person like that it's a pleasure, isn't it?

A: Yes. I became very interested in river engineering, and that has been my profession ever since. Even today, I say that river engineering is my primary interest.

Universities Specializing in Hydraulics and Sedimentation

Q: Berkeley was one of the leading universities or the leading departments of civil engineering specializing in hydraulics and sedimentation at that time.

A: Others were Iowa, Cal Tech, and Minnesota. Iowa was noted for theoretical fluid mechanics and small-scale types of experiments, not exactly the practical hydraulics part of hydraulic engineering, although they did a lot of theoretical work. The great Hunter Rouse was there, of course.

Cal Tech was quite busy because of Vito Vanoni. I knew Vanoni quite well because Einstein had worked with Vanoni and drew on Vanoni's important work in the transport of sediment in suspension. But the schools that were really busy in hydraulics, you might say the practical aspects of it, were Berkeley and the St. Anthony Falls Laboratory with Lorenz Straub in charge at the University of Minnesota [Minneapolis].

I got to know Straub, Rouse, and Vanoni as well as Einstein. They all consulted with the Corps of Engineers in the 1950's, and the laboratories at Berkeley, Cal Tech, Iowa, and St. Anthony Falls all did quite a bit of work under contract with the Corps.

Q: There were only a few places that did that type of work.

A: At that time.

Q: Right. In the '40's and '50's.

A: And shortly after, oh, in the '50's when Maury Albertson went from Iowa City out to Fort Collins, then Fort Collins [Colorado State University] became eminent and maybe pre-eminent in the area. Berkeley became less active in hydraulic research. And St. Anthony Falls, with the death of Straub, St. Anthony Falls faded away. Meanwhile, Maury Albertson moved from Iowa to Colorado State and then Darryl Simmons emerged at Colorado State. The program at CSU became, you might say, the most famous or pre-eminent program. They had graduate students from all over the world and so forth.

Q: Did Berkeley decline because O'Brien left?

A: No, Einstein died. Joe Johnson retired. I think they became more interested in the academics and less interested in doing commercial model work. Berkeley, as had Iowa, became more interested and remained interested in the theoretical aspects and in teaching and didn't really get into the business of turning out hydraulic Ph.D.s and Masters degrees as Fort Collins subsequently did.

Q: Well, it's interesting because when I talked to Jake Douma about his time. . .

A: He went to Berkeley.

Q: He went to Berkeley, and he worked under O'Brien. He knew O'Brien, who, apparently, was just working with his little laboratory there, his model operation, and just had gotten that started in the early '30's.

A: Right.

Q: By the time you left and then in the '50's that apparently faded away.

A: When I was there, which was from the summer of '47 through the summer of 1950, O'Brien was just a senior figure on high. He was Dean of Engineering, but I don't think he was that active. That must be toward the end of his career.

Q: Did they still have that laboratory?

A: Oh, yes. Well, not physically and not specifically. The laboratories they have may be the descendants of the laboratories they had when I was there, but they are not the same laboratories. There's one out in Richmond, California, which wasn't even there when I was there. But the big hydraulic laboratory today is out in Richmond, California. Then there's a laboratory in the new civil engineering building that was constructed after my time.

Q: It's always interesting to see how some of these programs change.

A: I think it has to do with the interests of the individual professors and the basic objectives of the school. At Berkeley, teaching was always the primary job of professors. I think it still is.

Q: Rather than experimentation, modeling, and practical applications?

A: The professor was expected to be eminent in his field, but his job was teaching students.

Q: That's interesting, because when I talked with Jake Douma, he was saying how the best courses he had were with some of the professors like Etchevary and Derleth, who taught based on practical experience.

A: Yes, they were the best courses, and they were also some of the most famous professors. Joe Hildebrand in chemistry, he taught freshman chemistry. It was Berkeley's philosophy that these eminent people should have contact with the students when they first get into the field. Of course, Einstein taught all of the hydraulics courses. So did Joe Johnson. O'Brien taught fluid mechanics.

Professor Joe Johnson

Q: Tell me a about Joe Johnson.

A: Well, during World War II Berkeley became quite involved in maritime engineering, shore engineering, wave studies, wave engineering. Berkeley had a research facility in which they created waves against artificial beaches and watched the transformation of the waves, the movement of sand on beaches and so forth. Joe Johnson was involved with this. They made studies in the surf. They studied diffraction and refraction theory of waves. The idea was that you could take aerial pictures of wave trains, and from those you could get an idea about the configuration of the beaches upon which the Marines were going to land.

They had some DUKWs [amphibious trucks], you know, these water-going land-going vehicles, which they drove through the surf on beaches along the Pacific coast and studied surf conditions for correlation with the aerial photographs.

So they became quite well-versed in ocean wave mechanics, beach erosion, shore processes and shore protection. This held over after the war, and Joe Johnson was in charge. There was what they called the Beach Erosion Board. This was under the auspice of the Beach Erosion Board. Joe Johnson was quite prominent in those enterprises. You probably ran into that when talking to some other people.

Coastal Engineering Research Center (CERC) and Thorndike Saville

Q: Yes, CERC is very familiar.

A: The Coastal Engineering Research Center, CERC.

Q: I know that very well.

A: Okay. Well, that's a creature of the Beach Erosion Board.

Q: Yes, the Beach Erosion Board later became CERC.

A: As a matter of fact, Thorndike Saville . . . you know his father?

Q: Yes, I know of them.

A: He was then a very well-known civil engineer. Then Thorndike Saville, Jr., eventually became the Director of CERC. You know that?

Q: Yes.

A: He was my classmate at Berkeley.

Q: Is that right?

A: When I was working away on flumes studying sedimentation processes and armoring of the bottoms of rivers, he was over in the facility that was making waves and studying sediment transport by waves.

Q: Well, he was down at CERC at Fort Belvoir for a long time, until they moved CERC to Vicksburg, Mississippi.

A: That's right. He became the director of CERC.

Q: I believe he was director from the early '70's until it moved to Vicksburg in about '83 or '84.

A: Yes, that's right. He came out of that tradition, the Beach Erosion Board and the studies at Berkeley, and then he went on to CERC.

Q: I guess he's still in this area down here, too.

A: I think he probably is. I sort of lost track of him. I haven't talked to him for years. He's a very fine gentleman.

Prominent Classmates from the University of California

Q: Did you have any other classmates who went on to have any prominence in the Corps?

A: With the Corps?

Q: Yes, or in engineering in general.

A: Well, I guess I had some successors there as Einstein's students that became quite prominent--Hsieh Wen Shen is now a professor there at Berkeley in civil engineering. Jim Harder and David Todd remained at Berkeley and eventually became Professors of Civil Engineering in hydraulics and sanitary, respectively. Ning Chein remained with Einstein at Berkeley for several years, but eventually returned to China and became one of their leading sedimentation experts.

Q: Okay. I'm just trying to put together some of your personal contacts, people you may have known or worked with early in your career.

A: But Saville was Joe Johnson's student, and I was Einstein's student. Joe Johnson had been there a while. But, as I think I mentioned before, when I arrived at Berkeley, Einstein had just arrived there from Cal Tech, and so I was really his first graduate student.

Q: At Cal?

A: At Cal, yes.

Q: Well, he'd been at Cal Tech for some time.

A: Yes, he'd been at Cal Tech during the first several years. That's how he knew Vanoni down there. When he came to this country, first he worked for the Agricultural Research Service at Greenwood, Mississippi. Some of his publications were from the laboratory there. Anyway, he ended up at Cal Tech where he was for several years, and then he ended up at Berkeley where he was for the rest of his career.

Q: Did you have much knowledge or instruction at Berkeley on hydraulics as they were developing around the world in addition to learning some things about what were going on in the U.S.?

A: I became fairly well-versed in river processes. Of course, they're going on all over the world, you might say. But in terms of the politics or the professional associations worldwide, I wasn't involved except through Einstein, where he may have had a consulting job he was doing or a paper he was writing, and I may have done the computations for him or did certain work for him in connection with that paper.

Transfer of Hydraulic Concepts and Technology from Germany and Europe

Q: One of the things that the historians in the Corps of Engineers have been looking at is the transfer of technology and concepts to the U.S. from Germany, the hydraulic engineers in Germany and Europe. Specifically, they are interested in some of these uniformed engineers who went to study with the German hydraulic engineers in the 1920's and '30's on Freeman fellowships and brought some of those concepts back. A number of American engineers, such as General Pat Casey, and a few others also went over there on Freeman fellowships from the American Society of Mechanical Engineers [ASME].

A: Of course, they were well-known names at that time, but I wasn't associated with them. I think in our profession, I guess the exponent of bringing the European experience in the theoretical field of fluid mechanics was Hunter Rouse because he spent a lot of time at Karlsruhe in Germany where he became a descendent of the [Ludwig] Prandtl and [Theodor] von Kármán school of fluid mechanics. He became quite eminent in the United States because he introduced the same principles of fluid mechanics after he joined the Iowa Institute of Hydraulic Research at the University of Iowa.

Q: One of the things we're looking at is not only the transfer of concepts but also of technology.

A: Hans Einstein had a strong mathematical background, which is not surprising. He was into bedload transport, but from a statistical point of view. He was a statistician, which probably took a leaf out of his father's notebook. He came via Switzerland, and his earlier works were quite mathematical, quite full of mathematic statistics.

Q: Well, isn't that a lot of what the sedimentation business is though?

A: Well, that's what Einstein brought to it. Another immigrant from Europe was Kalinske. We must give him some credit. He also introduced sedimentation as a statistical process. That's how Einstein became pre-eminent in bedload transport. He handled it as a statistical process in which an individual sediment particle moves intermittently, step-by-step, along the bed. A particle waits on the bed for the hydraulic conditions at that spot to be right to pick up the particle and move it one step along the bed, after which it waits for conditions to be right for another step, etc. The hydraulic conditions at the bed vary with time, statistically, and that's one concept Einstein introduced to the technology.

Q: The statistical part?

A: As opposed to the concept that the hydraulic drag on a particle, once it exceeds a certain critical value, pushes the stone along the bed. This is the "critical tractive force" approach probably initiated in the 18th century by [Pierre-Louis-Georges] Du Buat [1734-1809] and followed by many other investigators.

Q: Whenever we come to some of these things, you can assume I know nothing. I may know a little, but I don't know a lot. So you should make whatever explanation is needed for me to understand.

A: I don't know as much as I used to know. I forgot more than I knew.

Q: That's true of everybody, I think. You can make whatever explanations you want on what you're discussing.

A: Okay.

Thesis Work on Sedimentation and the Interest of the Corps of Engineers

Q: Now, at Berkeley your thesis was on sedimentation?

A: My thesis was on sedimentation and specifically on armoring. When you have a river bed that has a mixture of sand and gravel particles, the sand particles, the smaller particles, may be moved very easily, but the gravel particles may remain behind and move only slowly or not at all. Then, if you're below a dam where the sediment from upstream gets cut off, the finer particles get transported on downstream and a lot of the coarser particles tend to remain behind. Pretty soon, the bed becomes covered by this gravel armoring. The process is called armoring. That's what I studied in the flume at Berkeley for my thesis. The title of my thesis was, it sounds like a social treatise, "The Segregation of Grain Sizes in a Degrading Bed".

Q: Basically, you were studying just the process you talked about?

A: Yes, I was filling the flumes full of a couple of feet of a mixture of sand and gravel, and I was turning on the water, letting the water wash the material on downstream into a hopper at the lower end of the flume, and then keeping track of what remained back on the bed. Basically, I was interested in how much of this coarser material did you have to have on the bed before you literally armored the bed so you wouldn't get much sediment transport anymore.

This research was paid for by the Corps of Engineers, the Missouri River Division (MRD) of the Corps of Engineers. Once I started not doing just classroom work and computations, but actually getting out and defining a thesis topic, I went out and started my research in the field and designed my experiments to be performed in the laboratory. Once I started doing that, then this was oriented towards a specific problem that the Corps of Engineers had on the Missouri River. At that time they were getting ready to build five big dams along the Missouri River. They had built Fort Peck in the late '30's.

That was really before my time, professionally. But they were getting ready to build Garrison, Oahe, Big Bend, Fort Randall, and Gavins Point. They knew that below these dams they were going to get just this armoring process that I was describing to you. The question was just how much would the river degrade downstream from the dams. The reservoir releases would continue to transport the sediment on the river bed downstream from the dam. Since this material would no longer be replaced by sediment transported from upstream, the result is a net removal of bed sediment for a distance downstream from the dam. This causes both the river bed and the river water surface to lower. This process is called degradation.

The Corps was very interested in this because they were going to build power plants at these dams, and they had to design the power plants having in mind how low the tail water of the dams might degrade after several years of operation. Francis and Kaplan turbines will not operate properly unless they have enough tail water, enough back pressure over the tops of the turbines. So the Corps was interested in predicting the amount of tail water as limited by the armoring process. In the powerhouse designs they needed to know how low to set the turbines, the power generating units, to anticipate the ultimate degradation of the river levels below the dams. Anyway, my research was paid for by the Missouri River Division of the Corps. That's when another very significant person in my life got into the act, Don Bondurant. Have you run into his name before?

Don Bondurant and Employment with the Omaha District

Q: I have, yes.

A: He was the person from MRD who came out to Berkeley. He and Einstein were great friends. Einstein had done work for the Albuquerque District where Bondurant was at one time. Einstein had been a consultant on sedimentation problems on the Rio Grande. Bondurant came out to Berkeley, periodically, while I was doing my flume experiments on degradation and armoring. One thing led to another, and in 1950, he recruited me to go back to Omaha to work for the Omaha District of the Corps. The dams still had not been constructed. I was asked to continue my work on degradation and on river engineering work in general on the Missouri River.

The Mainstem Dams on the Missouri River in the Early 1950's

Q: You were there during the design phase on those dams?

A: Yes. I came in 1950, so you might say I was in on the design phase of all of the dams, except for Fort Peck. For Randall and Garrison, the design was well underway at that time, but still there was significant work to be done.

At that time, the Missouri River Division had, let's see, five districts. There was the Fort Peck District in Montana which just oversaw, measured, and observed the maintenance and operation of the dam and sedimentation processes in the Fort Peck

Reservoir, which had already been built and closed in the 1930's. There was the Garrison District which was a construction district that was formed just to design and construct the Garrison Dam, which was just above Bismarck in North Dakota.

The third district in MRD was Omaha District, which covered the Missouri Basin from Bismarck downstream all the way to the Kansas-Nebraska border, except for the Platte River in Colorado. The Omaha District designed and constructed four Missouri River Dams: Oahe Dam, just upstream from Pierre, South Dakota; Big Bend Dam, just downstream from Pierre; Fort Randall Dam, which was down near the South Dakota-Nebraska border; and then downstream from Fort Randall was a smaller dam called Gavins Point, which is at Yankton, South Dakota. The Omaha District also designed and constructed numerous dams, levee projects, and other local flood control projects on the Missouri River and its tributaries.

The fourth MRD district was the Denver District which was established to plan, design, and construct dams and flood control works on the South Platte River and tributaries around Denver. The fifth MRD district was Kansas City District which covered the Kansas River Basin, the Osage Basin, and other tributaries that enter the Missouri River between the Kansas-Nebraska border and St. Louis. By the 1960's the Fort Peck, Garrison, and Denver Districts had been added to Omaha District, so today MRD has only two districts, Omaha and Kansas City.

The six Missouri River Dams were world-class. Garrison, Oahe, and Fort Peck, at that time, were three of the largest dams in the world, both in terms of the volume of the reservoirs and in terms of the heights and volumes of their earth-fill embankments. The six dams could store three times the annual flow of the Missouri River above Yankton, South Dakota, just to give you an idea of the order of magnitude of control that they might have on the flows of the Missouri River that originate from the Dakotas, Montana, and Wyoming. The result has been that since 1952 the river above Yankton has not contributed to any floods on the lower Missouri River.

In addition to the space in the reservoirs for temporarily storing flood waters, there's a large carryover storage, or conservation storage, in the Missouri River reservoirs. The idea is that the conservation storage space is filled during normal and wet years so that they can continue to provide water supply for power and navigation, irrigation, recreation, and carry the system over a long drought as in the 1930's. We knew that operation of this major reservoir system would completely transform the Missouri River channel and flood plain. Flooding out of the river channel would be nearly eliminated downstream to Omaha and greatly reduced in frequency as far downstream as Kansas City. Although the dams would intercept all the sediment load from upstream, the river below the dams would continue to transport its active sandy bed.

The result would be degradation of the bed and lowering of the river water surface for miles downstream. This would cause far-reaching changes in the environment of the river channel and adjacent riverine lands.

The longer the dam construction period continued, the longer we studied them, the more knowledge and insight we gained as to what the effects of this dam construction would be all of the way down the Missouri River and into the Mississippi River below St. Louis.

Q: When you do the amount of work you are describing, the long-term effects are not readily visible, are they?

A: Well, they were there to be intuitively reasoned out from the principles we had at that time. We didn't call all of the shots. We understood quite a bit, but we learned more and more as we went along.

Work in the Omaha District's Sedimentation Program

Q: So you actually went to work at the Omaha District based on what you had done as a graduate student?

A: That's correct.

Q: So you had a good familiarity with what you were going into?

A: I was sent there to add some academic background to the sedimentation program on the Missouri River.

Q: And when you got there, you were assigned to the general hydraulics section?

A: Right. I was not assigned to the sediment section in the Omaha District. I was assigned to the general hydraulics section, which was run by a gentleman, a very fine engineer, named Nick Barbarossa. I don't know if you've run into his name.

Nick Barbarossa and the General Hydraulics Section

Q: No.

A: I worked for him for about a year. He was a hydraulic engineer, but was also interested in theoretical background. He had been to Columbia University. His professor had been Boris Bakhmeteff. I don't know if you've heard his name before or not.

Q: Yes, I've seen that name before.

A: A very famous name in open channel hydraulics. Under Nick Barbarossa I learned quite a bit about open channel hydraulics, how to compute and model open channel water surface profiles in rivers, and flood control channels, and steep chutes, and backwater profiles for reservoirs, and so forth. I learned quite a bit about the open channel hydraulics business that first year in addition to doing field research in the Missouri River on sedimentation, working with the sediment section of the Omaha District.

Calculating Backwater, Flood, and Water Surface Profiles

Q: You said that you learned a lot, so were Nick Barbarossa and the Omaha District doing work that you normally didn't see in the academic community or just not at Berkeley?

A: In Omaha I encountered practical applications of hydraulics to which I was able to apply my academic background from Berkeley. In 1950 the Corps was starting to design five dams on the Missouri, and we had to determine the backwater profiles from the reservoirs impounded by the dams. We also computed flood profiles along rivers for the purpose of assessing flood damages and designing levees along the stream to contain floods. We also computed water surface profiles for the design of man-made flood control channels.

Q: Was this all done mathematically or did you actually do modeling?

A: It was done by numerical computations, solving a first order differential equation that describes the water surface profiles in steady flow. On certain situations where it was very important or a very complex local situation, we did go to the laboratory and do some modeling. But, in general, the major part of the work was done with hand computations. Nowadays they call it numerical modeling, numerical computations, solving a series of differential equations that you get for open channel flow. You compute the water surface profile along the system, taking into account bridges and other obstacles, channel cross section changes, inflows from the side of the channel, etc. I call it numerical computation or numerical modeling.

Q: But that was in the pre-computer days. . .

A: That was pre-computer days, right.

Q: So was it all by mechanical calculators or slide rules?

A: I used a slide rule. Some people used mechanical calculators. There's very little work that's done in open channel hydraulics where you need the precision of many decimal points that you would have to have with a calculator. I used the slide rule for my work because that precision was good enough for the work we were doing.

Now, the structural engineer, if he were computing the height of a concrete wall, or the highway engineer, if he was computing the profile of a highway, or actually computing the height of a wall, he would have his calculator and he'd be putting out the dimensions to the thousandths of an inch.

Q: Yes, that's also what Jake Douma said.

A: The water surface profile for a major river, this may be heresy, but if you get the water levels to the nearest foot, that's pretty good. Sit on a river bank sometimes and watch the water surface. Certainly, a tenth of a foot is very high precision. Maybe Douma told you the same thing.

Q: Well, yes, he did. He said he had seen some studies that had three or four decimal points, and he asked, "What's the purpose of this?"

A: To impress the uninitiated about your study.

Q: Well, he said one of the things he found out by inquiring from somebody, I think it was on one of the projects in southern California, Santa Anna River or something, that the guy didn't know how to do anything else but use the computer.

A: Use the calculator.

Q: Yes, well, this was a little later when they were using computers. He said all he knew was how to put some numbers in and the figures would come out with two or three decimal points.

A: Well, that's the problem today. We use these so-called backwater programs, they call them. HEC-2 is the famous one. A lot of people are very well-versed in the lore of how to feed data into HEC-2, but I'm not sure they know what it means. I'm not sure they know what the results mean or can look at the results and tell whether it makes any sense or not, in many cases.

Margaret Petersen

Q: Did you know Margaret Petersen who was there in the Omaha District in the early '50's?

A: Oh, yes.

Q: She said exactly the same thing that you're saying about people who relied completely on the calculator or the computer. I think she was referring to the HEC-2 sort of program where some of these students were just putting figures in and coming out with all of these decimal points. She said they didn't know what they were talking about.

A: It was a source of irritation to me sometimes because when we asked subordinates to compute the water surface for certain special situations, we would hear, "Well, I can't. HEC-2 doesn't do it." That sort of thing which exposed their limited grasp of hydraulics and dependence on "cookbook" solutions really exasperated me.

Q: That HEC-2 program is probably from the Hydraulic Engineering Center, too, isn't it?

A: Yes.

Q: A Corps-developed program?

A: Oh, yes. It's a Corps-developed program. Let me tell you about Margaret Petersen a little bit.

Q: Okay.

A: Nick Barbarossa, I only overlapped with him for about one year. Then he took a job as a professor at the University of Minnesota with Lorenz Straub. Then I inherited his job. We were the general hydraulics section of the planning and reports branch of the engineering division of the Omaha District office. The Missouri River Division office, which was in charge of all of the five districts that I mentioned to you earlier, was also in Omaha. Well, a year or so later, Nick came back to Omaha. His association with Lorenz Straub at Minnesota didn't work out the way he wanted it to, and so he became disenchanted about being a college professor.

He came back, and this time he ended up in the Missouri Division office. For several years, then, he was up there in the division office overseeing a part of the hydraulics area while I was down in the Omaha District. I, originally, had charge of the general hydraulics section and pretty soon, I also had charge of the sedimentation section, also. It became the hydraulic and sedimentation section for several years.

Margaret Petersen and her friend, Irene Miller, obtained their Masters Degrees in Hydraulic Engineering.

Q: They were at Iowa.

A: Iowa, that's right. They came to work for Nick in the Missouri River Division office. Then, after a few years, they went down to Arkansas where there was quite a renaissance of dam building for navigation along the Arkansas River. After a few years, Margaret went out to Sacramento District from which job she retired and went to the University of Arizona. Margaret went on with her career as a college teacher and then as a consultant.

Frank Campbell

Q: Was Frank Campbell out there then?

A: Frank Campbell was the hydraulic designer up in the design branch in the Omaha District. I was not in the same branch. I was in what's known as the planning and reports branch. That's where the sedimentation, and the open channel hydraulics, and the design of local flood protection projects was. And, of course, when you get a local protection project that has a diversion and maybe even a spillway, letting water flow over the hill or through it, you get into the design of concrete spillways and conduits. I'm afraid I got into conflict with Frank Campbell a couple of times because I was treading on his toes. But that's the way it was. Later, when I worked for MRD, I took on the hydraulic design of the larger structures.

Early Computer Usage for Studies of Reservoir Operations

Anyway, they [Margaret Petersen and Irene Miller] were in the Missouri River Division office for a couple of years around 1954, so I knew them here at Omaha. That's when the Missouri River Division was just getting into the computer business. I don't know if you knew that or not.

Q: Yes.

A: MRD had a contract with Raytheon. They were interested in the computer business, not from an engineering computation point of view, not from the point of view of the things I've been describing, but doing reservoir operation studies for the six-reservoir system that was being completed and about to go into operation. They had dozens of studies in which they operated the reservoir system on paper over the period of record for flows on the Missouri River. The purpose was to optimize the operation for flood control, downstream navigation, and power production. All these operation studies were done tediously by hand. MRD recognized this was a made-to-order application for the new computer technology.

For years MRD had this big contract with Raytheon Corporation in which they got time on the old UNIVAC. There was a mathematician called Otto Steiner that worked for Nick up there along with the two women, Margaret and Irene. They were involved in that aspect of hydrologic engineering, but not in sedimentation, because Don Bondurant, whom I mentioned earlier, was in charge of sedimentation at the division office. And, you know, in many offices of the Corps, the individuals guard their bailiwicks very carefully. They don't tolerate much overlap.

Q: Oh, yes.

A: I don't know if Jake Douma ever told you about that or not.

Hydraulics and Hydrology in the Omaha District and Missouri River Division

Q: Oh, yes. I've had it from both sides because I also interviewed Vern Hagen. So I've gotten the hydrology part plus the hydraulics part.

A: I was lucky. I was able to bring to myself hydraulics and hydrology, or hydraulics and sedimentation, and then eventually hydrology, all under my own auspices. These guys in some of these other offices weren't that lucky. They always stayed to their own bailiwick.

Q: Well, it seemed that at the district, and Jake mentioned this, that the districts and divisions had combined hydraulic design and hydrology much earlier than it ever came together at the level of OCE.

A: That's right. There was a hydraulic designer that worked for the structural people in the design branch, and they did the hydraulic design for the big hydraulic structures, like the dams, the spillways, the intakes and outlets and that sort of thing. But the Corps was also doing a whole lot of local protection projects where there were miles and miles of levees, and channel diversions, and small spillways, and small structures and weirs, and bank protection, and all kinds of things like that.

That's what I was involved in. I was involved in the smaller structures, the banks protection, the river channels stabilization, this sort of thing. So we did a lot of hydraulic design, but for the local protection projects. The design of the major hydraulic structures was done by the hydraulic designer who was up in what was then the structural section. I like to think that I had the interesting work which was creating, evolving, conceiving these projects, trying to make them work, trying to decide how to keep these small towns and areas from being flooded.

Q: Well, you're looking at a larger picture than just the structure. You're looking at the impact of that structure.

A: We're looking at a system of structures, the whole project working as a whole, yes. That includes hard concrete structures, rock structures, channels, levees, and all of that sort of thing.

Q: Yes, that's a lot more difficult than just. . .

A: Not more difficult, but it's more comprehensive. It's more interesting.

Omaha District

Q: Exactly where did the hydrology piece fit with what was going on in the Omaha District?

A: Hydrology was with the planning and reports branch.

Q: So that was with you?

A: I was not in charge of the branch, but I was in what became the hydraulics and sediment section in that branch. That branch had a report section with which we all worked as a team. We all cooperated in conceiving and laying out the project. The report section formulated the projects economically, got the local cooperation lined up, and wrote the justification for the project. Then there was the reservoir regulation section, and they were the ones concerned with getting ready to operate these reservoirs once they were constructed.

Also within the planning and reports branch was the hydrology section which did the classical hydrology, translating a storm and rainfall into floods, and estimating the discharges at various points along the stream system. Then there was my hydraulics and sediment section which took the water that hydrology had predicted and either designed the projects to carry the water or made computations to decide how high the floods were going to be, with or without the project in place, to be used by planning to determine average rainfall flood damages and the benefits of the project.

That's how we were divided up. We worked as a team. We worked in cooperation and in close association with one another for several years. And if I may say so, we did excellent work. I think we became pre-eminent in the Corps.

Q: Well, how many people then did you have in that particular branch?

A: The hydraulic and sediment section?

Q: Yes.

A: Well, the number varied over the years, but I had 40-50 people.

Missouri River Division

Q: Let's discuss your work as chief of the hydraulics and hydrology branch in MRD.

A: Okay.

Q: You were in that position in the division for fourteen years.

A: Oh, in the division, I was there from. . .

Q: '64 to '78, right, before you became chief of tech engineering.

A: Yes.

Q: What was the biggest technical engineering challenge you had in that period when you were chief of hydraulics and hydrology?

A: Well, I think maintaining a good staff and providing the support to the districts for their particular problems. That's what we tried to do. Sometimes we and the district didn't see eye-to-eye, so we had to be very tactful while we were trying to be persuasive.

Q: Which district gave you most trouble?

A: Kansas City.

Q: Kansas City. Was that just because of the distance or something else?

A: Well, no. Kansas City always had their own way of doing things. They were conservative and not very flexible in how they addressed problems. We had to persuade them to try new approaches.

Q: Did you find in your experience in the Corps that you did run into districts like that?

A: The districts have characteristics. For example, Omaha District and MRD, the first day I arrived as a junior engineer, everyone was on a first name basis. Wendell Johnson was Wendell. Jerry Ackermann, the chief engineer in the district, was Jerry. I was Al, and so forth. Now, in Kansas City, they're all "Mister". I'm just saying there was a different culture in that office back in the 1950's and '60's. You run into offices like that around the Corps. Some are more formal and some are less.

Q: That's interesting, but it's a culture that's developed, isn't it?

A: Yes. Sometimes there was a very strong individual who was in charge for years and years. He just more or less established the character of the organization.

Q: I was also wondering though, with Omaha, with all of those big dams projects, how much did people coming in from other districts and divisions to work in the district give it more of a cosmopolitan flavor. Whereas, Kansas City didn't have a lot of those big projects. They had a lot of projects, but they didn't have a lot of those huge projects.

A: Down on the Kansas River basin, they had some big projects down there.

Q: Right. But I mean they didn't have anything near what you had in the upper Missouri there.

A: No, they didn't, but they had their share of big projects. I don't know. When I say Kansas City was a big problem, they were harder to deal with than the Omaha District. Let me just put it that way. They were a very competent engineering organization.

Q: I was just speculating, having been to a number of districts and having talked to a lot of people from districts, that Kansas City was more of a home-grown district, with a lot less mobility by the key civilians.

A: I think that's probably the case. Up until later, in the middle years, around 1980 or so, they began importing people from outside the Kansas City District into the openings in the Kansas City District. So that could have been a factor.

Q: In some of these districts the same people spend their whole careers in a district. They never leave.

A: That's right. Well, I never left Omaha.

Q: No, but you did move up to the division. Like you say, once you go from the one office to the next higher headquarters, your perspective changes markedly.

A: I had opportunities to move, but I didn't move.

Q: You liked Omaha?

A: Well, I liked what I was doing. For example, I never in the world would have gone to OCE. I thought I had more freedom of action, both more freedom and more scope, in Omaha than I ever would have had in Washington. Because Washington is organized, each person jealously guards a certain area, a certain bailiwick. Maybe you've noticed that.

Q: Oh, yes, yes, very much so.

A: You know, I just liked to wheel and deal across the line. It's a matter of going where my interests lie. I'd be in trouble in a hurry in Washington, probably.

Q: Well, I think the problem up there is that the smaller the empire, the more vigorously you defend it, right?

A: Anyway, that's one of the reasons I stayed in Omaha. Although, I'd have been much better off financially because if I'd bought a house in Fairfax, Virginia, and stayed there maybe ten years I'd be in a lot better shape contemplating a move to another part of the country. Right now we are contemplating a move, but Omaha is a relatively low real estate market. Almost any place we would want to move has higher real estate values.

So anyway, I was content to stay in Omaha until the last few years, and then I retired because the bureaucracy, the fighting for the life of the organization for funds, wasn't what I liked to do. I finally retired and started private consulting probably two, three, or four years after I probably should have.

Q: So you got back to doing what you really wanted to do?

A: Yes.

Q: Your perspective increased vastly when you moved to MRD because you now had the whole division to work with and both Omaha and Kansas City Districts. Was the management part then a lot more difficult for you?

A: As a first line supervisor, I had more people working directly for me in the district than I ever had in the division. But in the end, when I was chief of technical engineering in the division, I directly supervised only the section heads and was the second line supervisor for the rest of the branch.

I guess it was a lot more difficult in the division in the sense that one was forever trying to justify the personnel spaces that you had. You had to fight to keep your organization staffed and alive, deal with budgetary problems, justifying personnel spaces, seek awards or advancement for deserving employees, contest for spaces within personnel ceilings, recruit excellent candidates to fill vacancies, and so forth.

At the district, these projects were designed for construction. There was plenty of money. This was design money, and we did what we had to do to build the project. We didn't run into the fiscal constraints that we ran into later in the division when these projects started to be completed. We got into operation and maintenance, and the money was not as widely available as before. So I guess my management problems were more difficult in the division.

Q: Well, the division has always been a problem because of the way it's funded, isn't it? It takes funds from both of the districts in your case?

A: Yes. The division doesn't receive funds directly. The division has to take General Expense funds, as you say, from the district offices. The division doesn't have any direct funds except in the Reservoir Control Center. They get a direct allocation of O&M funds because they have an operating function.

Q: Do they control all of the reservoirs?

A: Yes. The rest of the people in the division are just oversight. They siphon off a percentage from the district offices.

Chief, Technical Engineering Branch, Missouri River Division

Q: Let me take you through your time as chief of the technical engineering branch.

A: All right. Tech engineering in Omaha had all of the engineering disciplines, except for geotechnical engineering. In other words, I had a mechanical and electrical section, and hydraulics and hydrology, and architecture, and structural, and environmental engineering, which is what they called general engineering, which is where the cost-estimating and the coordination of reviews and so forth is done. So all of those functions were in technical engineering.

Q: Why if it looks like everything else that pertained to any kind of project work is in your branch, why not geotech?

A: Oh, it was probably individuals. Geotech had the laboratory, and in MRD had been separate from technical engineering since the 1950's.

But anyway, we had all of the disciplines except for geotech. We had an excellent staff. I questioned the wisdom of elevating all of these people up in the division reviewing peoples' work. They were nationwide experts in their fields. It would have been nice if the Corps could have organized so that many of these key people with their capability and experience could have remained down at the district level actually guiding the design of projects rather than just looking over people's shoulders and reviewing. But the personnel guidelines were such that in order to receive promotion they had to work at a higher organizational level.

Q: Well, that's always the problem though, isn't it?

A: What did we have, 22 people? I don't know. Quite a few, all GS-13s, except for three secretaries.

Q: But a lot of them go for the promotions so you move upward.

A: And then they're taken out of the mainstream of doing useful work.

Q: Well, what about the technical engineering experience, the technical engineering branch experience, that you remember as specifically significant?

A: Well, I don't know. You were right where all of the problems were and the action was because of the nature of the branch and the disciplines that it covered. But I don't know that there was anything new. The tech engineering branch was essentially the same that it had been for years, except that they put hydraulics and hydrology into it, and near the end of my tenure hazardous waste became a major involvement.

Q: When you went in there?

A: Yes, I went in there. I was head of hydraulics and hydrology for several years before I became chief of the tech branch.

Q: Right. What about the working relationships with planning division?

A: I always had good working relationships with planning. Particularly early in the game, the chiefs of planning were personal friends. We had mutual respect, and I had good relationships with them.

Sediment Section Field Teams

Because we were closing these dams, we had field crews out observing the sediment piling into these reservoirs, surveying ranges, observing the behaviors of the river downstream from each one of these dams. So we had a number of field crews. Eventually, when Garrison and Fort Peck Districts were combined with the Omaha District, in addition to Omaha District's original sedimentation field crews, I had a field crew up at Fort Peck and a field crew at Garrison. The field crews went out and did what we call aggradation and degradation surveys in the reservoirs and downstream from the dams continually nine months of the year during the open river season. They were very competent people operating fairly independently in the field. Between the field crews and the engineers in the office working on sedimentation and doing hydraulic computations for formulating and designing flood control projects, we had a large group.

Q: It must have been quite large with all of the dams and the projects that you had and all of that sampling equipment that they used.

A: Oh, yes, sampling equipment. Our field man who worked with me, who was probably the most eminent one, is Bob Livesey, I don't know if you've run into his name.

Q: No. What was his name again?

A: Bob Livesey. But he was responsible for the success of the field crews in the Omaha District. He did not have a complete college education, but he was a very good organizer and good leader and did an excellent professional job.

Q: Was the reservoir regulation section responsible for the guidelines to operate the reservoirs?

A: Correct. The criteria for operating reservoirs. And also, eventually, when the reservoir started to be operated, they kept track of the day-to-day operation of the dams, too, in terms of keeping track of the water that comes in, and letting the water out, this type of thing.

The counterpart organization in the MRD office is called the Reservoir Control Center (RCC). The RCC actually specifies reservoir releases so there is probably some overlapping of functions between RCC in the division and the reservoir regulation section in the district.

Change from the Missouri River Division to the Missouri River Region

Q: Well, I guess all of that's going to change now, isn't it, with the division going away?

A: The name Missouri River Division is going away because they're going to call it the Missouri River Region, but the offices are all going to have the same players.

Q: So I guess the Omaha District is going to go back to being large like it used to be. It was a huge district at the time of the '50's and the '60's.

A: That's right. Well, it's not going to be called a division office. It's going to be called a regional office. The jobs for a lot of the technical people will be phased out. The new office won't have the same functions anymore. They can't actually do technical reviews or studies. They'll have the technical oversight over the districts that they used to have when I was around, but this required fewer people. It's a different situation now.

Q: Yes, they've put that up another level?

A: No, they abolished technical reviews above the district level. The regional office will only do cursory technical oversight, quality assurance (QA), if you will.

Q: Abolished it entirely?

A: The great strength of the Corps of Engineers as an effective engineering organization was, in my opinion, the philosophy that every major engineering decision got two levels of review, both by the office that's busy doing the work and then there was an oversight and a review of some sort from another office. It might have been the division office or maybe there was a separate organization up at the district to do that, but there were two levels of review. This was a philosophy of sound engineering on which the Corps built its reputation. That's all been abandoned now.

So there's a real question now within the Corps. I think there are some people concerned in the Corps as to whether we are really getting effective quality assurance.

Then there's quality control (QC). Well, the district gets quality control by reviewing their own work. Then the regional office is supposed to provide quality assurance by doing technical oversight over the reviewing process in the districts. The former division office is now down to a very few technical people who can really perform this quality assurance that I've just been talking about.

Q: Now are they expecting this all to fall back to Civil Works at headquarters to do this?

A: Headquarters has no capability at all for doing any of this. So I don't know what's going to happen. I don't think the people in charge, I don't think they're fully aware-- maybe only I consider it a problem because I mean no one did it as well as we did it in the old days, this sort of thing. Maybe they don't consider it a problem at all.

Q: Well, the one thing history teaches you is that most organizations don't learn from it, and they go off and do silly things without thinking about their consequences.

A: Well, they do silly things, but they're running out of people that really are experienced, that really can recognize how some of these things should work. That's a different subject, you know. My career with the Corps was over ten years ago.

Q: I understand that. But when an opening comes up and you mention something, I'm going to ask a question.

A: But I think we've got several billion dollars worth of reservoirs lined up along the Missouri River that represents a tremendous potential public hazard unless they are properly cared for. I think we are gradually eliminating the people who can properly evaluate these and watch them year-by-year. We're going to do it under contract. We're going to have the lowest bidder come in and inspect these dams every few years. But where's the continuity?

Q: Well, that's what you don't get with a contractor.

A: Someone has to be familiar with the history of, say, Oahe Dam, and know about the problems they've had with slides and the abutment, have the background to guide the program of dam inspections and instrumentation, and continually monitor the dam and all its major structures. Evaluation of all this data for dam safety requires experience and continuity. I only hope the district will be able in the future to staff for this responsibility, especially in the geotechnical field.

Planning and Completing Diversions at Fort Randall, Garrison, Gavins Point, Oahe, and Big Bend Dams

Q: From the early '50's and into '64 it had to be a very exciting time in Omaha District with all of those big dams going up.

A: Oh, tremendous construction. At that time, I got involved in the closures, the diversions of these dams, a hydraulic problem. How do you shut the river off and force the water through some other route, either through the power plant or through the tunnels so you could complete the construction of the dam across the river? That's one of the first things I got into in the second year. I got into a lot of these diversions, first at Fort Randall in July 1952, and then in 1953, Garrison District did the diversion of Garrison. I observed that. I was involved in the diversion of Gavins Point in 1955 and of Big Bend Dam in 1960. Probably the most important diversion operation was the one at Oahe at Pierre, South Dakota, in 1956.

Q: Would you take me step-by-step through diversion planning?

A: When you build a dam across a major river, you don't have the ability to shut the river off upstream. The time comes when you're building the dam, usually from both sides, and you get the river narrowed down as narrow as you dare. You have to leave the gap wide enough so the river can be passed without flooding. And then there comes a time when you're going to have to extend your dam across the remaining width of the river and complete the dam.

Meanwhile, you have constructed means to convey the water past the dam site as the river channel is being blocked. At Fort Peck, Garrison, Oahe, and Fort Randall, the river flow was diverted through the flood control and power tunnels. At Big Bend and Gavins Point, diversion was through the skeleton power unit which formed sort of an open flume before the power turbines were installed.

Now you have to do something in the river gap to raise the water surface upstream from the construction site to create enough head to force the river flow through the diversion facilities that you have prepared.

This is done in several ways. Of course, the easiest way is when you've got to dam upstream, as after Oahe had been completed and we were ready to divert at Big Bend just downstream. We just shut the gates at Oahe, and soon the flow was reduced to only a few hundred cubic feet per second at Big Bend. The upstream part of the Big Bend embankment was then constructed in the gap, and when outflows from Oahe resumed, the flows diverted through the skeleton power units.

But we didn't have that luxury in Fort Peck, Garrison, and Fort Randall, which had to be diverted before we had significant control of the flows from upstream though we could shut the river off at Garrison and at Fort Peck. So you've got to block this channel some way.

It was done in several different ways on the Missouri River. For example, at Garrison and at Fort Peck, they built a bridge across the narrow river gap. Then they dumped rock from the bridge from the dump trucks and brought up a rock weir across the river, trying to keep the weir crest at an even elevation over the whole thousand feet or so of river gap. The water level began to rise as the water washed over the length of the slowly rising rock weir. Pretty soon the water level rose high enough upstream to force part of the river flow through the tunnels. As the water level upstream from the rock weir rose higher and higher, more and more of the river water was diverted through the tunnels, and finally, with a final effort, the weir was topped off and came out of the water. The entire river flow was then going through the tunnels, and the diversion was completed.

At Fort Randall, we did a similar diversion weir a thousand feet long except that there was no bridge and chalk rock was dredged in to bring up the weir. We had a huge 30-inch cutter head dredge that dredged in chalk rock to raise a weir evenly up across the whole width and divert the river flow through the flood control tunnels. We had a diversion gap that was only two hundred feet wide.

Oahe Dam, which was ready for diversion in 1956, was a different proposition. Since Garrison was then in operation upstream, we could plan to reduce the river flow to 6,000 to 10,000 cubic feet per second (cfs) for the diversion operation. The contractor at Oahe had tremendous earth moving capability. They broke some of the records for moving earth when they constructed the Oahe Dam. To accomplish diversion they used a lot of bulldozers and large dump trucks, and over a period of a day, dumped shale rock into the diversion gap from both sides. After a period of maybe 20 hours, they literally choked off the river flow and then continued to dump material to raise the diversion fill several feet above the rising water surface. Meanwhile, the pool upstream from the diversion fill continued to rise, but there was no outflow at first because the inverts of the tunnels at Oahe were six feet above the river level. It was the next day before water started flowing through the tunnels and the upstream pool had to rise ten feet to put the river flow through the flood control tunnels of Oahe. This was the most sensational operation because we created about a ten-foot head. We literally were dumping the rock in faster than the river could carry it away. We couldn't stop dumping because once the upstream pool stopped rising, the river inflow would stop going into storage in the pool. Then the full river inflow plus the outflow from the emptying pool would discharge through the diversion gap. All the dumped material would be washed out, and wash material downstream. We'd have to start all over again. That was an interesting operation.

Early Computer Modeling in the Omaha District

Q: That had to be very carefully orchestrated.

A: Well, it was. This was in 1955-56, I've forgotten the exact day. Anyway, this is the first computer modeling enterprise that I know about. We wrote a program for the IBM 650, using a language called Bell-2, and actually did a full-fledged modeling effort. The reason we had been able to do that was that a couple of years or so earlier, having done hundreds of backwater computations by hand, we came to recognize that this was a made-to-order application for the new computer technology. We then had more access to computers. We had this Raytheon contract where they were using UNIVAC, and the IBM 650 was just coming into use commercially with installations at banks and insurance companies in Omaha and elsewhere.

We wrote a backwater program for computing water surface profiles. It turned out that at the same time the potential of the computer for this application had been recognized in several places in the country. The Soil Conservation Service out in Washington was writing one, and probably before we did. The Tulsa District was writing one for the Arkansas River, and that became the progenitor of HEC-2.

But we, in the Omaha District, developed our own "backwater" program for simulated water surface profiles in rivers. The first version used the IBM 650. We used to go and rent time elsewhere until eventually we got one of our own in our office. So we had had some experience with the computer when the Oahe diversion application presented itself. I wrote the simulation, and we ran many simulated diversions for a wide variety of physical conditions. This helped demonstrate the feasibility of the proposed method of diversion and helped in planning the construction operation. It was an interesting operation. It worked out pretty much as we calculated, strange as it may seem.

Q: Now, that was very early in the history of computers?

A: Yes, that was '54-'55. I'd have to look up the exact dates.

Q: Did you get someone to help you as far as tell you how to write a program or is that something that you just experimented with?

A: Well, at the very beginning for the backwater program, what I did was make a flowchart of the problem, showing step-by-step what I wanted to do. Then I gave the flowchart to one of our engineers, a very enterprising brave person named George Lathrop. He went home one weekend and learned the IBM 650 assembly language. Eventually, he took the flowchart and programmed it in IBM assembly language. We started that way.

We did not have FORTRAN in those days, but Bell Labs had come up with Bell-1 and Bell-2, which were languages designed for engineering use. So I wrote the Oahe diversion simulation in Bell-2. But we had to go up to Minneapolis to the IBM Service Bureau in order to run the simulation.

Then a couple of years later, the FORTRAN came in. By that time, companies like IBM, RCA, and CDC came out with series of modern computers with lots of core storage and very fast access. On these we could program in Fortran. Then from then on, from 1956 on, I programmed strictly in FORTRAN, which I could still do today, if I had to.

Q: So you basically continued to develop your own programs?

A: Yes.

Q: Was there anything commercially available then to solve your problems?

A: No. If there was one that was usable, we used it. We sometimes paid to have one developed for us, and sometimes we'd develop it ourselves, and so forth. So, over the years, we wrote lots of simulations, lots of programs, and used them.

Q: Did you try to market this program that worked for Oahe in the Corps?

A: No, it was single-purpose. You know you don't divert the river at Oahe very often. We wrote a paper on it for the ASCE Hydraulics Division Conference at Cincinnati that showed it could be done.

Q: For that one dam?

A: Yes, it wasn't a general diversion program. The principles were all general. They applied. You could put it back together in a different way for another project.

Q: So you didn't have any computer program for Fort Randall and Gavins Point?

A: Randall and Gavins Point were earlier. Besides, the diversion schemes were different. They had a simpler situation than Oahe. For the Fort Randall diversion, the deposit of chalk rock along the weir crest was assumed to create a succession of stable weir profiles. Theoretically, anyway, the water could keep running over it for hours and days, and the weir would remain stable. The computation is based on the assumption of a series of static conditions.

Now, Oahe was different, and that's why we had to use the computer because it was dynamic in that all of the time you're dumping rock in, water was carrying it away. So the rate of dumping had to be greater than the rate at which the water was taking the rock away or the weir wouldn't rise. In fact, if there were a pause in dumping rock, the weir would wash out. The computations for this dynamic simulating were too extensive to do by hand. That is why we had to get into using the computers.

Pretty soon, you get a configuration that's high enough--the higher you get your water level upstream, the more the water is going around the end, through the diversion tunnels that you created. Eventually, you get it high enough that all of the water is going through the diversion and the weir comes out of the water, and then you just compute how much water that represents in your weir. That was a static thing.

Again, Oahe was different. We had to use the computer because it was dynamic in that all of the time you're dumping rock in, water was carrying it away. There was a rock or a sediment transport equation that was hauling the rock away. So the rate of dumping had to be greater than the rate at which the water was taking the rock away or the weir wouldn't rise. So it was a dynamic and unsteady state situation, and that is why we had to get into the use of the computers.

The same is true of water surface profile computations. For steady state flow, we can sit down and compute by hand anything that HEC-2 can do. It takes longer, but we could do it as we did prior to the computer era. But as soon as you let the flow start going down the river in a flood wave or a surge where you have temporal variations with the water rising and falling, the whole situation is changing with time as you go along. Then it gets so complicated that you just don't have enough people to compute it by hand. Then you have to use the computer. Computation of these dynamic flow situations was only feasible after the computer came along.

Q: That's where the computer really makes a change in your business.

A: A good example is dynamic flood routing using the theoretical equations. Prior to computers the full computation was not feasible. But today, there are many dynamic flood routing programs available. They all solve the same differential equations.

Q: And you used to do the flood routing by hand?

A: We didn't do numerical flood routing by hand. It was too big a job. We did some engineering types of computations that were approximations like the Muskingum method or the Puls method of routing. There were certain approximate routing methods that were used. But we never did do routing very precisely, very accurately, until we could actually start computing these things with the computer. It was too big of a job to do by hand.

Q: Wasn't that based on getting some practical information, also?

A: Well, none of this is practical, from an engineering point of view, unless you've got some field measurements to verify the results of the computation and provide the basis for adjusting the computed results.

But, actually, if you don't have any field data, that's perfect for the guy who is just grinding out computer results: Answers to the seventh decimal point. Beautiful artwork. Beautiful graphs. It looks like a million dollars.

Q: But it has no relation to reality, right?

A: But as soon as you get some reality, then you're in trouble. You have to adjust things to that.

Q: Tell me about Don Bondurant.

A: Okay.

Don Bondurant

Q: You mentioned him earlier, but I really don't know much about him. I was wondering if you could tell me about him and the positions he held in the Missouri River Division at the time and subsequently.

A: I'll tell you what I know about him. I think he graduated from the University of Arkansas, and he was with the Corps of Engineers from the 1930's through his retirement in the early 1980's. He was on the construction of the Mississippi River dikes and revetments back in his earliest days, in the '30's.

Then he finally found his way during the war years to the Albuquerque District of the Corps. They were building some dams in the Arkansas River Basin in the late '30's, at the end of the depression, when dams like Hoover Dam and Grand Coulee came into being and the Corps of Engineers had some projects like Denison Dam in Texas and Fort Peck in Montana. I think Don was in the Corps at the time they did John Martin Reservoir and Conchas Reservoir on the Arkansas River Basin.

After these projects were completed after the war, he went to the Albuquerque District. At the time there was more and more interest in the discipline of sedimentation. He became the person who oversaw the area of sedimentation which was important because they were working on trying to regulate bank caving and channel shifting on the Rio Grande River through Albuquerque and on downstream.

He engaged in some very extensive studies on sedimentation, became quite familiar with the people in the Soil Conservation Service working on the same subject. In Albuquerque they hired some consultants. Among the consultants was H.A. Einstein, who was then with Cal Tech. They worked on the means of stabilizing the Rio Grande River through Albuquerque and down Elephant Butte Reservoir. He was one of the earliest engineers in the Corps to become interested in sedimentation.

Then the Missouri River Division began to staff up to build the five large dams along the Missouri River below Fort Peck, and so he moved in the late '40's. He moved from Albuquerque to Omaha and became the head of the sediment section in the Missouri River Division office.

I think I told you last time we talked that in connection with building these dams, it was known that when you put some dams across a major alluvial river that you're going to have major effects on the river regimen and the adjacent environment both upstream and downstream of the dam. You're going to get degradation downstream and all kinds of other effects from the regulation of flows, and you're going to get backwater effects from the reservoir.

I guess part of his job was to predict these effects so timely action could be taken. So he started several critical courses of action. He engaged in a contract with the University of California, with Einstein being the principal investigator, for investigating degradation downstream reservoirs and the armoring phenomena where the fine grains segregate from the coarse grains in the river bed material and the coarse grains more or less armor the bed and slow down the rate at which the bed degrades. That contract was one that I worked on when I was a graduate student.

Missouri River Sediment Advisory Board

Another activity that Bondurant engaged in, MRD formed the Missouri River Sediment Advisory Board. I don't know when its first meetings were, probably in the very late 1940's. They had some of the eminent sedimentation people on the board. Einstein was on it. Vito Vanoni from Cal Tech. Thomas Means was a prestigious engineer from the old U.S. Reclamation Service which became the Bureau of Reclamation.

Another person on the advisory board was Lorenz G. Straub, who was the head of the St. Anthony Falls Laboratory and head of civil engineering at the University of Minnesota. Then there was Gail Hathaway from the Chief of Engineers' office in Washington.

Those were the five people on the Sediment Advisory Board. When I arrived on the scene in the fall of 1950, the board had already had several meetings and was discussing various questions concerning the closure and the operation of these big reservoirs. But Bondurant was the guiding light behind it. He assembled these people, and they met at least twice a year. Each meeting had a topic, like the aggradation in the headwaters of Garrison Reservoir at the town of Williston, for example.

There was one topic that was always a major topic, whether we needed to relocate the town of Niobrara [Nebraska], just above the head waters of Gavins Point Dam, where the Niobrara River enters the Missouri River and so forth. There were questions of degradation, how much is the bed going to degrade? How much is the water surface going to lower below these dams?

I think I explained last time that the problem was that they wanted to set the power units low enough. If the water level drops below a certain point, you don't have enough back pressure on the units and the units are subject to severe damage due to cavitation. So you have to have a certain draft head or a certain back pressure on the turbine unit in order for it to operate without severe cavitation damage.

And, of course, when you start digging down into shale foundations and chalk foundations, you encounter high excavation costs and also you increase your risks because deep excavations in shale materials are likely to encounter weak seams and other sources of instability.

Q: This Missouri River Sediment Advisory Board must have been relatively unique in the Corps?

A: Yes, it was.

Q: Did other districts or divisions then follow that lead and establish other sediment advisory boards like that?

A: Well, you say districts and divisions. This board was for the entire Missouri River Division. Each of the districts on the Missouri River used the board. I believe the Southwestern Division established one down on the Arkansas for the series of dams that they built along the Arkansas River. I think that Einstein did some consulting for them. Whether they had a full blown engineering board, I don't know.

Anyway, Bondurant was the guiding light behind the Sediment Advisory Board. He did not do technical investigations himself. He tried to assemble people who were well qualified to do this. He was acting like the coach, you might say, sort of the entrepreneur that put together the various idea people that could address the problem. He finally retired around 1980. If you want the exact date, I can get it for you.

Q: He spent most of his time in the Missouri River Division?

A: Well, after he was down in the Memphis District and then whatever district he was in when they built the John Martin Reservoir, then the Albuquerque District. Then he was in the Missouri River Division of the Corps from the late 1940's until his retirement in about 1980.

Q: So he was not in the Omaha District?

A: He was never in the Omaha District as far as I know. He's really the father of the effort that was made. I personally think, although he's not well known, he deserves quite a bit of credit.

Hydraulics and Sedimentation in the Omaha District

Q: Now, in the district itself, when Nick Barbarossa left, I gather he was the head of the hydraulics and sediment section.

A: No, he was the head of the general hydraulics section.

Q: Okay, general hydraulics.

A: And I worked for him. We were mostly concerned with open channel hydraulics for computing the profiles of floods for the purpose of figuring flood damages and justifying projects, and then figuring the water surface profiles within the channel improvements and levee projects that we designed for flood protection. Another person, a man named Billy Mitchell, was in charge of the sediment section in the Omaha District at that time.

Q: Okay.

A: Although Nick was a practical hydraulic engineer, he was also a fluid mechanics person. In other words, he, like myself, brought in the new discipline, theoretical discipline, of fluid mechanics into the picture and sort of imposed it on the more or less empirical art of river hydraulics.

Q: So you replaced Nick when he left?

A: Yes, Bondurant put me there when I left Berkeley. He thought I would do the most good there. After Nick left, for a time I was the head of the general hydraulics section, and then within a year or so, Billy Mitchell left, then I inherited the sediment section, also. Then I became the head of the hydraulics and sediment section.

Q: Okay. I was just trying to get some of these relationships clear for myself. Now, who was head of planning and reports in the district when you went there?

A: The head of planning and reports in the district when I went there in the fall of 1950 was Jack Gardner. When Jack Gardner retired after a few years, Russ Wiethop became the head of the planning and reports branch.

Q: Okay.

A: Fortunately, for my entire time with the district, which went up to the year 1964, the planning and reports branch was in existence. After that time, they split it up, much to the detriment of coordination. That's only my personal opinion.

The Emergence of Planning and Organizational Restructuring

Q: Was that when planning became a more prominent feature?

A: Yes, there was a planning section in the planning and reports branch. Maybe all bureaucracies are this way, but the Corps had a habit, probably still has a habit, if there is, you might say, a subject of the year, they would break out a new organization and give it a title that reflects that subject. For example, the subject of the year that came along about the time I left the Omaha District was basin-wide planning. Maybe some Congressional bill decreed that our planning was supposed to consider comprehensive basin-wide effects economically when we looked at our projects. And so the response of the Corps was, "Well, we're going to show Congress we're doing that." So they created a new branch in the Omaha District and called it the Comprehensive Basin Planning Branch. They pulled some of the report people out and put them into the new branch, They fractionated reports. That was the result.

Q: Comprehensive basin planning?

A: That was the watchword of the day, so therefore, the Corps dictated that each office should have a branch called comprehensive basin planning. There have been other examples over the years. For example, they decided that cost estimating wasn't being done very well. Then they dictated, "You are going to have an independent branch called the Cost Estimating Branch in every Corps office." And therefore it was done.

Anyway, these things result in fractionating an organization. It might create the emphasis that they desire, but some organizations were already working very well and then they were fractionated. In the bureaucratic turmoil that's created, the new organizational element is elevated to a branch or to a higher status, and pretty soon you've got all of these functional organizations running in parallel to each other, all with equal status. It may work well while the same people are still there. Then when the individuals who have been working together retire or leave or die, you've got people who haven't worked together, each in charge of his or her individual organization, and then very often close cooperation suffers and you get concerned about maintaining prerogatives, and bailiwicks, and so forth.

Q: Turf battles?

A: That's right.

Omaha District's Engineering Division under Jerry Ackermann

Q: Who was the chief of the engineering division in the district at that time?

A: The chief of the engineering division when I first--in the Omaha District?

Q: Yes.

A: It was Jerry Ackermann. And then a very prominent, strong person, Wendell Johnson, was the chief of the engineering division up in the division office.

Q: Johnson had replaced Frank Slichter.

A: In MRD, Johnson replaced Slichter who went on to the Chief's Office to become the chief engineer. And, of course, Johnson subsequently again replaced Slichter, this time at OCE.

Q: Tell me a little bit about Ackermann.

A: Well, he had the talent to really get everybody working together. Everyone respected him. Of course, I was a junior, more of a junior engineer, for a good share of the time that he was there. But from my observations in the Omaha District, things ran very well under Jerry Ackermann. People respected him, deferred to him. He led the district at the time all of these big dams were being designed and constructed. I believe you might say the Omaha District was pre-eminent in the dam planning and design field at that time, worldwide.

I don't think Jerry had a degree. I think he came up during the '30's and during the war, but he had such good leadership abilities that he fell into this leadership job. I think he had a technique for recognizing the right person to do the right thing and to pull everything together. As you can see, I have great respect for him.

Q: Yes. Jerry Ackermann is a name we've come across, but we don't necessarily know a lot about him.

A: Another great man, an engineer's engineer was Ed Soucek. Have you run into him yet?

Ed Soucek

Q: No.

A: He was the chief of the design branch up in the Omaha District all of this time. He subsequently became chief of technical engineering up in the division office.

Q: So he was responsible for all of the design of the mainstem dams then?

A: The design. Ed was a fantastic, interesting person. He was a genius. He's one of these people that can play two or three games of chess blindfolded, and so forth. He was quite prominent back in the early '40's in the Panama Canal Study when they built the second set of locks in the Panama Canal. He was in that project. And then he came up to the Omaha District at the time they were staffing up to build these huge dams.

He was a very interesting person. He liked to hunt mushrooms. He played the violin. He went to school at the University of Iowa. He was interested in the academics. He's got a couple of papers in hydraulics published. He and I hit it off quite well. He basically came up through the hydraulics discipline. He was a very fine gentleman. I don't know whether he's still alive. He retired finally to some place in Iowa, but he was the Corps' resident genius.

Q: Well, that's one of the problems when you have an organization like this. If they don't come into prominence up at the headquarters, sometimes you don't get anything about them.

A: Well, they all knew him.

Q: Well, they would have, yes.

A: Wendell, Jerry, they all knew Ed Soucek.

Wendell Johnson

Q: What about Wendell Johnson, from your dealings with him?

A: Well, Wendell, he was in the division for maybe no more than a year after I came to Omaha District. Yet I knew him, and he knew me. Wendell was a real gentleman. In my career with the Corps, in the offices I was in, everyone was on a first name basis. The chief engineer would be on a first name basis with the junior engineer that was just hired. And, of course, he had everyone's respect. He made good decisions. I think he was originally an electrical engineer.

But, you know, that distinction, the kind of engineering you studied in school, or even if you have a degree, that distinction becomes less and less important as you go along and you develop experience and your career develops, and you're in, you might say, the right places at the right time.

Q: And also, as you establish your own credentials, I imagine.

A: That's right. And show your abilities and so forth.

Q: Right.

A: But Wendell Johnson was a very fine person and a prestigious engineer. He finally ended up in the Chief's Office, and then finally retired from that job.

Q: Did you ever meet or deal with Slichter at all?

A: No, I never met Slichter. To me he was just a name that everyone mentioned and respected, because he'd been in the Missouri River Division office and his signature was on some of the early designs.

Q: He was a key associate of Lewis Pick.

A: Now, you interviewed Slichter, didn't you?

Q: We have interviewed Slichter, right. Marty Reuss did that interview. Slichter's well into his 90's.

A: He's a remarkable person.

Q: But the person that put us on to Slichter--we all thought he had passed away-was Frank Snyder. I interviewed Frank and Frank said, "I got a Christmas card from Slichter."

A: Now, if Ed Soucek happens to be alive, he'd be one you should talk to.

Q: Well, that's one thing, too. If there are people you think should be talked to, please let me know.

A: I can make some inquiries. If I went back to my office now, I doubt if anybody even remembers Ed Soucek. In my opinion, he was just about the engineer's engineer. He was a true genius.

Q: But that happens in any organization. It happens relatively quickly, you know, in an organization.

A: Yes.

Åke Alin

Q: Did you ever deal with a man by the name of Åke Alin?

A: Sure. He was sort of the resident hydraulics consultant for the Omaha District. I suppose in the early days, he probably worked for the Omaha District.

Q: Yes, I gather he was in the engineering division.

A: Yes, he had a desk there, although he was always a consultant when I knew him. They consulted him on spillways and hydraulic structures. He was professor of hydraulics at Iowa and taught one or more hydraulic courses over at Iowa City, although he lived in Omaha. He hated to fly. Would not fly. And so every week on Tuesday, he'd get on the train--those were the days when we had trains--he'd get on the train and head for Iowa City, and then Friday, he'd come back by train. He'd spend his time in Iowa City teaching his course.

But he was a well-known consultant, worldwide, I believe, basically on spillways. They called him "Okey" Alin. And his real name was Åke. He's a Swede.

Q: Right. With the little zero. I gather his last name was Alin.

A: Yes, that's correct.

Q: Margaret Petersen knew him well and talked about him.

A: Yes, she knew him.

Q: Apparently, he was in the engineering division at some time, I think, in the division.

A: That was well before Margaret's time, and before my time that he was actually an employee of the Corps.

Q: Yes.

A: He was sort of a perennial consultant. And, as I say, the Omaha District actually maintained a desk for him there.

Q: So he would come in and help.

Contacts with Hydraulics Personnel at the Office of the Chief of Engineers

I'd like to ask you about your contacts with people in hydraulics at the Office of the Chief of Engineers (OCE). Did they encourage you to go up there, did they send you up to the headquarters to meet those people?

A: Oh, certainly. I knew Jake Douma very well. Of course, Jake was the structural hydraulic guy. I also knew the hydrology people like Al Cochran quite well because the sedimentation and all of those disciplines were over in the hydrology part of the Chief's Office. At that time, Brice Hobbs was the sediment person in Hydrology.

Gail Hathaway and the Spillway Design Flood

Q: Now, tell me about Hathaway. I met his daughter some years ago, when I was in the Corps of Engineers. We were able to obtain his personal papers. He's sort of a legend in the Corps, of course.

A: Well, he was probably responsible for the Corps' reputation of designing dams for very large floods. In other words, dam safety was the watch word of the day at that time. He developed, basically, the design floods that the Corps used to make sure the dams had adequate spillways so that there was minimal danger of them being overtopped. This design flood was called a Spillway Design Flood. So Hathaway was responsible for a lot of the hydrology that resulted in the size of many of our dam spillway structures. The public safety was paramount, and still is.

Q: I was going to ask you that because one of the questions that was looked at by some people doing some work on Corps hydraulics is why the spillway at Garrison is so huge. It can handle 827,000 cubic feet per second, which is very large.

A: Well, I'm not familiar with the details for Garrison, but basically the Corps assumes the coincidence of a number of extreme events and critical conditions of the water shed. For Garrison, I'm sure they considered an extreme accumulation of the snow pack on the Northern Plains, a combination of rain and early freeze that froze the ground under the snow pack, a very rapid warm-up to melt the snow in the spring, an early spring rainfall on top of the snow, etc. To some degree these coincidences have occurred in the past to produce the great floods of historic record.

Now, the thing is, if you look at the picture, historically, we've approached these floods someplace in the world. When you're sitting with the Missouri River, with these huge reservoirs upstream from great cities from Sioux City down to Omaha, Kansas City, and St. Louis, you can't take any chances at all. So that's why Garrison has a huge spillway. The spillways of all the Missouri River Dams were designed with this philosophy.

You know, you don't get big floods unless you've got unusual coincidences of events and unusual preceding conditions. So you've got to combine all kinds of events in order to get them. In nature, that's what produced the extreme events that stand out in the historic record of floods. We can probably attribute this philosophy to Gail Hathaway.

Corps of Engineers and Bureau of Reclamation Dam Design Criteria

Q: His entire approach on these things significantly varied from the Bureau of Reclamation, didn't it?

A: Well, I don't know what the Bureau of Reclamation did. All I know is that they've gotten into trouble more than once with dams failing. And the Corps, oh, we had one fiasco out on the Alamagordo Reservoir when a flood that occurred during construction showed that the spillway was inadequate, so they never filled the reservoir. But as far as I know, no Corps dams have been overtopped. It can happen, but you'd have to live a long time. The Corps is very conservative because public safety is paramount when you put a dam across a river with thousands of people living downstream.

Q: Right. You can't take chances with that. I guess that was one of the things Hathaway really stressed. That was his sort of legacy.

A: And that's how the Corps came out with, I think, a better reputation for safety than the Bureau. The Bureau had some real black eyes there. They are now going around systematically revising a good share of their projects in the west.

Q: Rebuilding them, or adding to them, I think.

A: Putting in more capacity for spillways and so forth.

Q: Jake was involved in some of their dams.

A: Yes, I think the Bureau put a greater emphasis on the flood of record in designing their dam spillways.

Q: Especially when we don't have records going back more than a hundred and fifty years.

A: The Corps took some interesting approaches in hydrology studies. For example, in order to look at the cycles of drought and cycles of high rainfall, they hired a dendrochronologist. Do you know what that is?

Q: No, what?

A: That's someone who looks at tree rings and analyzes them. If you find an old enough tree, you can find out which are the wet years and which are the dry years over a period of hundreds of years. They did everything, including dendrochronology, to improve on the historical streamflow record.

Q: Thoroughness.

A: Yes.

Q: Absolutely. So you think a lot of that comes from Hathaway's stress on design?

A: It's one of his contributions, the idea of designing safe projects with conservative spillways. There's a saying in the Corps that there's a design flood, and there is a maximum historical flood, and then there is a "Hathaway flood". We designed for the Hathaway flood. But he retired shortly after I was on the scene, within a year or so. I only met him a couple of times because he came to these Sediment Advisory Board meetings, so you can't say that I knew him.

Q: Well, he's one of the great figures in the Corps' history.

A: That's right.

Q: But nowadays, most people don't know who he was.

A: No.

Q: That is unfortunate. That's one of the reasons we've got this project underway, to look more into the history of the Corps' hydraulics and hydrology activities.

A: That's right.

Other Contacts at OCE

Q: So your primary contacts at OCE were the people in hydraulics and hydrology, Al Cochran, Frank Snyder.

A: Well, over the years, I think that hydraulics and hydrology. Let's see, of course, we talked with the structural people. I had contacts with the geotechnical people because I got into the wave protection business and that was in the geotechnical area of the Chief's office. And then the planning business, because we were concerned with economically justifying projects. I got into the business of modeling flood damages and so forth.

Later in my career, when I was in division and became the technical engineering branch chief. I inherited military construction, so I got involved with people on the military construction side in the Chief's office.

Q: Did you always find your contacts to be helpful? I know that in the past some people have mentioned that the Chief's Office wasn't necessarily helpful to them.

A: You know, a person in the lower echelon is always reluctant to admit that the higher echelon was helpful. The people in the district probably winced every time I came down from the division to look over what they were doing. When you get higher up, you tend to miss the direct involvement with projects. You become a frustrated designer and planner and so forth. You have to resist it. There's a temptation to stick your finger into where you really shouldn't because you interfere more than you really should.

Q: Well, that's one of the things that one of the former Chiefs of Engineers, "Weary" Wilson used to say. The problem was that you have to know your level. He always said that the guy who wanted to be a practicing engineer should never be a district engineer or chief of engineering. If you wanted to be a practicing engineer, you had to stay down at the lower level.

A: Once you get up to the higher level, then you've got to be real careful not to interfere with these guys who are actually doing the useful work. But, you know, the people in the Chief's Office, I think they wanted to give advice. They had great experience.

Al Cochran

For example, with Al Cochran, whenever he was coming to look over your project, the planning, your formulation of the project, it was a common story that if you knew Cochran was coming, you scheduled an extra day because once he starts talking he never stops.

Sam Powell

Q: But that sometimes is very helpful, isn't it?

A: Yes, I guess so. And Sam Powell always had quite a lot to say, too.

Q: As a matter of fact, I think he just retired a couple of weeks ago.

A: Yes, he just retired.

Q: So he's been around for an awfully long time.

A: He will probably be able to give you background on all of the people we have been discussing. Of course, he was in Portland District at the time of Hathaway. He overlapped Wendell Johnson in the Chief's office, of course. But he didn't overlap with Slichter. He left the Portland District to work for Jake Douma in Washington. Sam became Jake's successor.

Jake Douma

Q: Jake's been around an awfully long time.

A: Jake's been around since the year one. He was around in the '30's in the Los Angeles District where he did those concrete channels. Later he went to the Chief's office where he was in hydraulics until he retired and Sam Powell took it over from him.

Q: He was there from 1946 in the Chief's office.

A: He made a couple of tries to get me to go there to the Chief's office, but I made a personal choice that I didn't want to work in Washington, so I never accepted a job there. Might have been a better career choice if I had, I suppose. But I believed I had more freedom to do what I wanted to do and continue to do engineering the way I wanted to do it if I stayed where I was.

Q: Well, I'll tell you one of the things I noticed from a lot of the people who were up in OCE is that they did a lot of consulting work on the side. I think that was to keep their hand in the engineering part of it. That's what he stressed when he talked about the consulting work which he was doing while he was still working with the Corps and after he retired.

A: He did a lot of consulting. As a matter of fact, it was hard to get hold of him because he was often off in Pakistan or some other place.

Q: But I think what you highlight there is the desire to keep your hand in practical engineering.

A: That's correct.

Q: As they go up higher, like Jake and Frank Snyder, they're not doing that, they're managers.

A: That's right. Well, Jake didn't want to be a manager. He wanted to be an engineer. He's like, you know, we all understood each other. We had good rapport. Lloyd Duscha on one occasion tried to get me to go to Washington, but I didn't want to go.

Q: Well, life in Omaha could be a little bit more interesting than in Washington and easier. I lived there for a while myself.

A: Well, they all have their well-defined bailiwick. If you really have a lot of interest and start looking broadly at things, you start stepping on other people's toes and you get into trouble.

Omaha District Work with the Waterways Experiment Station (WES)

Q: Let me ask you about the Waterways Experiment Station (WES).

A: All right.

Q: What was the working relationship with WES when you were there in the district? How soon was it before you went down to WES after you first got there? For a person doing the kind of work you did, those kinds of relationships have to be very important.

A: Oh, I think I went down there the first year I was in the Corps. We went down by train. We took the Missouri Pacific down the Missouri River to Kansas City and then we took a train across to East St. Louis, I remember. Then they put you in a set-out car and you'd sit there on a track in East St. Louis until sometime during the night, the Panama Limited came down from Chicago and hooked onto your car. In the morning, you wake up in Jackson, Mississippi. I remember that. We flew home because the railroads were delayed by floods. I can remember it was the year of the great 1951 flood on the Kansas River.

Q: The 1951 flooding out in Kansas?

A: There was a lot of flooding all over the Middle West, especially in the Kansas and Osage River Basins. Anyway, that's when I first went down to Vicksburg, very early in the game. I've been going there ever since.

Q: What were your impressions of WES at that time?

A: Oh, big prestigious laboratory with people that could be very helpful with whatever we were working on. One of my early visits was to see the Mississippi Basin Model. They were using the Missouri section of the model to route floods down the Missouri River. Actually, the model wasn't in Vicksburg, it was at Clinton near Jackson.

Q: Now, did you use WES a lot?

A: Yes, we ran a lot of model studies at WES. Our major dam structures, spillways, outlet works, energy dissipators, and so forth were model tested at WES. We used it for a lot of special studies. We used CERC for wave riprap, but we used WES for riprap studies, and bank protection studies, all kinds of special channel problems.

WES and the Missouri River Division Laboratory

Q: What was the relationship between the MRD lab and WES? What did the MRD lab do? They didn't do any big modeling for you. What were they mainly doing?

A: Well, the MRD lab was the soils and material testing laboratory.

Q: So they were more focused on the geotechnical aspects?

A: Yes. I guess WES had a geotechnical lab, but MRD lab did all of the geotechnical testing, materials testing, for our projects. Now, back in about the late '70's, we did develop a movable bed river modeling laboratory at Mead, Nebraska, near Omaha, for studying bank protection and channel stabilization techniques for the Missouri River, using a light-weight bed material. Bondurant was instrumental in promoting this, and I oversaw the development of the modeling techniques.

If you use sand on a small-scale river model, you can't even get the sand to move, whereas the Missouri River moves sand bed very easily in suspension. So in order to get a small-scale model that moves the sediment easily, you have to use something light as bed material. We used ground walnut shells which have a specific gravity about 1.3 as compared with 2.6 for river sand. For quite a few years we operated this Mead Laboratory facility.

This was practically over Vicksburg's dead body. They did movable bed modeling and didn't want MRD to get into the act. But between Bondurant and Jake Douma, we got our lab. I think Jake liked to twist Vicksburg's tail once in a while to sort of keep them on the ball. So we got the Mead Laboratory approved and for several years we did quite a bit of model testing of river training structures and bank protection.

Q: Was that part of the work that was being done on channel stabilization?

A: Yes, partly, channel stabilization and also techniques for bank protection.

Channel Stabilization Committee Projects

Q: The channel stabilization and stream bank erosion committees were very good because they supported with experiments and ran tests in various rivers.

A: That's right. We could test various techniques at the Mead Laboratory, and we put a lot of it in the field. We had a streambank erosion study authorization from Congress where we were able to put in test sections on the river. This was for the whole Corps, and we had some of that money for the Missouri River where we had several test sections along the Missouri River. So we tried some of the techniques in the laboratory, and then we tried them on the river bank. The district is still observing these tests. It was Section 32 of one of the flood control acts, so these were called Section 32 Projects.

The Mead Laboratory was very helpful to us in studying these things. Vicksburg never did really acknowledge we were doing anything very useful. They were not very happy about the Mead Laboratory.

Q: I guess WES wanted to keep all of that work for themselves?

A: Yes, they did.

Q: They probably thought that if division starts this, then others are going to follow suit, and pretty soon WES will be out of business?

A: Yes. We had a problem in that they were very expensive.

Q: Yes, I've heard that.

A: Vicksburg's costs were quite a bone of contention there. Their overhead was high. It got so they couldn't even turn a valve on a model for less than $25,000 or $50,000. You could count on your model testing project costing a lot of money if you were going to do any testing at Vicksburg. So we worked with them closely to insure that the test program moved along and we were getting what we needed. One of the ways we worked with them when we had the people to do so, we sent one of our junior engineers down to work at Vicksburg on our model. That worked out quite well because that way there was always somebody working on our problem.

Q: When that person came back then he had a lot of knowledge you could use.

A: Sure. We didn't do all our laboratory studies at Vicksburg. Whenever we found an excuse to do it, we actually did special laboratory studies at one of the universities under contract, at Iowa, at Fort Collins, or at Berkeley. Sometimes we'd pay the university to run these tests, but usually we would lease the facilities and send one of our own people to run the tests. That also was very good for training young engineers.

Q: I imagine they were much more familiar with the conditions.

A: That's right. So we did a lot of model testing. Aside from controversy over the Mead Laboratory, we had a very congenial and fruitful relationship with the Waterways Experiment Station. They were old friends down there. The people I knew are all retired now.

Hydrologic Engineering Center (HEC)

Q: How about the Hydrologic Engineering Center (HEC) when that came on line in the '60's?

A: We had a lot of connection with them. We've gone to classes out there. I taught some classes and attended some classes there. Our hydrology people always had a close relationship with HEC.

Q: Do you think it filled a significant need when it was established?

A: I'm not sure whose idea it was. And, yes, I think they filled a critical need. They kept the Corps pre-eminent in hydrology for a long time.

Q: Al Cochran and Roy Beard pushed it, didn't they?

A: Well, Al Cochran promoted the idea of a Hydrologic Engineering Center and Roy Beard was the first director. It was their baby.

The Use of Consultants

Q: Okay. You've talked about the number of consultants that Omaha and the Missouri River Division both used. Your mentor, H.A. Einstein, but also Åke Alin and a lot of other ones. Who else were key consultants? We talked about the Missouri River Sediment Advisory Board.

A: We had [Arthur] Casagrande and [Karl] Terzaghi on an advisory board for the dams. I wasn't involved particularly with that. That's geotechnical work. But they were the top names in geotechnical engineering.

Q: So you could pretty much go out and get anybody you needed?

A: At the time. You know, in later years, somebody decreed we're not going to have as many big advisory boards. So the Corps used very few of those in later years. Someone decreed against them. I don't know what the argument would have been.

Q: You'd think that you'd want to get the best advice available.

A: I think it got criticism from Congress and so all of a sudden the Corps wasn't hiring many consultants. If you hire a consultant, now, you had to go out to the lowest bidder. You want to find an expert in chute spillway design, you've got to go out and get the lowest bidder. It was ludicrous.

Q: Rather than get the person who actually knew what they were doing?

A: That's right. With careful arrangements you might get who you want in the end, but new rules made it very difficult to have what you call consultants or consulting boards. I don't remember the rationale.

Surge Tanks on the Mainstem Dams

Q: Okay. I'm going to go to a real practical question now, away from those. I was looking at some pictures in some books I have here of the power houses at Garrison, Fort Randall, and Oahe, and they have these huge surge tanks above the power houses.

A: Yes.

Q: But Gavins Point and Big Bend don't have any at all. Could you tell me what's the difference? What's the surge tank for? I have an idea about it. Why do three of them have them and two don't?

A: Well, actually, four of them have it. Fort Peck has it.

Q: Fort Peck has them?

A: Big Bend and Gavins Point have concrete dam sections and the power house is right in this concrete dam section. There's no long tunnel or penstock leading up to the power unit. In other words, the intake was just 50-100 feet upstream from the turbine. When the turbine wicket gates open, water essentially goes directly from the pool and through the turbines. If there was a major power failure somewhere in the system the wicket gates close within seconds and as the gates close, the water comes to an abrupt stop and causes a pressure surge that is transmitted upstream. At Gavins Point and Big Bend, where the water passage is short, this water hammer pressure disturbance is absorbed by the upstream pool. You might get a wave that runs upstream in the reservoir.

But in Oahe, or Garrison, or Fort Peck, you might have some tunnels a half a mile or a mile long leading up to the power unit. If you have a rejection of load, which you get automatically if lightning gets the switch yard or something, the unit immediately shuts down, the gates close, and you've got a tremendous momentum of water approaching the closing wicket gates. You have got a tunnel full of water in a tube a mile long approaching the turbine and a speed of five or 10 miles per hour. Then you get a rejection of load. The turbine gates close and the water is fairly incompressible, and you're got that big tube of water coming at the turbine. As the water comes to an abrupt stop, it causes a water hammer effect that would burst the turbines and destroy the dam if there were no surge tanks to absorb the shock.

The surge tank allows the water to surge up into the surge tank and relieve the pressure. You get the same thing in your house, you know. If you turn off a valve really fast, you get a bump, don't you?

Q: Yes.

A: That's a water hammer. So anyway, the dams with long penstocks and with the potential for rapid closure of the wicket gates on the power unit have surge tanks to relieve the water hammer effects so you don't burst the penstocks.

Q: That's an answer. When you look at a picture of them, they're so obvious. They're like big grain elevators.

A: Oh, yes. And, furthermore, if you do the momentum, the impulse-momentum relationship, you do the physics of it, you'll find that the surge can carry higher than the dam, higher than the reservoir. That's why some of those surge tanks are really high. They come up above the dam.

Q: Yes, significantly higher.

A: Analysis of the power plant transients in penstocks and surge tanks is another field I was involved in. In the 1960's, first Nick Barbarossa and then I were instrumental in working with MIT [Massachusetts Institute of Technology] to come up with a computer program for simulating hydropower plant transients.

Developing WHAMO

Q: So you developed a whole program to do that?

A: MIT. That's right, Frank Perkins at MIT really was the person. But I was the Corps' principal investigator that worked with him after Barbarossa left MRD.

Q: Is that because of the experience you guys had out there in those mainstem dams?

A: Well, MRD paid for it. The idea was to make measurements, to make power plant transient measurements, in our hydropower plants at Garrison and at Fort Randall, and then try to use the data to verify the power plant transient program MIT was writing.

Q: And that information fit back into the design for other dams?

A: Yes. We used the verification data from the power plants we built to verify the computer program. Now the program is called WHAMO. It's used quite widely. It's in the public domain. WHAMO--Water Hammer Analysis and Mass Oscillation.

Two things. A water hammer is the pressure wave transmitted through the water column which is almost incompressible. Mass oscillation is the flow of water up or down the penstock upstream and downstream in the tunnel once you shut off the turbine. Water flows up the surge tank and then down the surge tank and upstream through the tunnel. Then the flow reverses and flows downstream through the tunnel and up the surge tank and so on. This mass oscillation goes on for several minutes after gate closure. In a properly designed system, the mass oscillations will dampen.

Q: I imagine you don't like that happening.

A: The surge tanks are designed to let the oscillation occur and relieve the pressure on the tunnel. There are a lot more intricate aspects of it. You can get resonance where the oscillation's built up. Anyway, you put orifices in the surge tank riser to dampen the flow to try to avoid resonance effects and so forth. We can simulate all of those with this WHAMO program.

Surge Tank Design

Q: We've talked about the mainstem dams. We talked last time about the surge tanks. I have another question about the surge tanks for you. What are the criteria for the design of the size of the surge tanks? What considerations determine their size? What is the capacity of the tunnel?

A: The considerations are the size and length of the tunnels, the velocity of flow in the tunnels, the height of the reservoir, the head on the lower end of the tunnel and the relative elevation of the reservoir upstream. An important consideration is the requirements for regulating the unit, that is, would the units be regulating units on line so they could be shut off almost within a few seconds, or will they run on base load and be shut off very slowly. Another consideration is the strength of the penstock. How much water hammer pressure can be tolerated.

I mentioned the rate of gate closing, the rate of wicket gate closing on the units. If they could be on base load and closed only very slowly, then you don't need much of a surge tank. But if you're going to close it in 5-10 seconds, then you need a much larger surge tank. You create a bigger water hammer pressure.

Q: Did the design of the tanks ever present any problems or the fabrication of them?

A: Well, they varied, concrete and steel. Ours were all steel. They're major steel structures, huge cylinders fabricated from steel plates. Their major construction problem is sometimes the surge tanks are of such a diameter, they have to roll the steel there near the site and assemble them there on the site. So it's a major structural problem. The early one for the first power plant at Fort Peck was riveted. The later ones, for the Fort Peck second power plant, Fort Randall, Garrison, and Oahe, are welded.

But they're major steel structures, and they have a problem with temperature stress. They sit in an environment where it gets to over a hundred degrees in the summer and might get to forty below zero in the winter. So there's a major change in temperature, therefore, the steel expands and contracts. You have to take those stresses into account.

So it's a major structural engineering problem to design them, and a major hydraulic engineering problem to decide what the dimensions should be to get the regulation that's needed and protect from the water hammer pressures.

Q: So that's just another added problem for the design?

A: Yes, just the design--there were experts that made a whole career out of the design of penstocks.

Penstock Designs

Q: Well, speaking about penstocks. What kind of design problems did they present? We talked about the surge tanks.

A: Oh, surge tanks. Penstocks. Well, first of all, that's just a word for the tunnel that leads to the turbine. Sometimes they're concrete, sometimes they're concrete with steel lining, and sometimes they're just a big steel structures fabricated from heavy steel plate. The old steel structures at Fort Peck are riveted. The newer ones are welded.

You've got some of the same problems. It depends on the head on the reservoir. That tells you what static pressure you're going to get on the lower end of the penstock. When you shut the gate downstream, you're going to get the full reservoir pressure. Then you have to know how much additional over-pressure is going to occur due to mass oscillation in the surge tanks. You have to know what the water hammer pressure might be, so you've got to design them for these internal pressures that might occur during operation of the penstock and surge tank system.

Q: So these are very, very, complex structures we're dealing with.

A: Oh, yes. These are very complex structures. You've got the temperature stresses. You've got the properties of steel, the brittleness or the plasticity of steel, the brittleness of steel to take into account. Sometimes there's a problem of brittle fracture which you want to avoid. The steel gets too cold, and so they are being constantly monitored, observed, and tested to make sure they continue to be safe during the life of the project.

Replacement of Penstocks at Fort Peck Dam

Q: Have any of those been replaced? Any parts?

A: Yes, I was involved in replacing the penstocks on the powerhouse at Fort Peck. They were originally built around 1940. They were riveted and the riveted plates were being displaced. It wasn't clear that they were going to fail, but we did replace them with modern welded-steel penstocks. The power tunnel at Fort Peck has a trifurcation at the downstream end. The flow is divided among three free-standing steel penstocks that lead to the turbines. We replaced the three riveted free-standing segments with new welded steel structures.

It had also been determined that the surge tank might not be adequate. There was a limitation on the loading of the units or on the rate at which we could close the gates because it was observed that the water rose in the surge tank up to within inches of the top during one power load rejection test that we made. So we made modifications in the surge tanks to make them safer for rapid load rejections.

In the process we restricted the orifice in the surge tank riser. This reduced the height of surge in case of rapid load rejection. In the process of doing that, we made the surge tank safer, but we increased the water hammer pressure in the penstocks. So that was another reason why we replaced the old riveted penstocks at Fort Peck with new and stronger welded structures.

Q: How much of a problem is it when you make the physical replacement of them?

A: Well, it's a major construction project. You've got to shut the upstream gate on the tunnel, unwater the tunnel and the penstock, tear out the old trifurcation and penstocks, and put in new ones. It's a major construction job. You need an experienced company that knows what it's doing to do that kind of steel work, bring in these big rolled-steel sections and weld them together, and stress relieve them, and fabricate the system in such a way it's safe and will not have problems during operation. All this must be accomplished in a very cramped space in the existing powerhouse.

Another thing that complicated the penstocks at Fort Peck was the trifurcation. At the end of the tunnel, you might say there was a bulkhead with three circular openings for the three penstocks that branch out from the bulkhead. The structural design of this trifurcation was very tricky and required an intricate stress analysis that takes into account water pressures, temperature stresses, stresses from structural deflections, stress concentrations, etc.

Q: How long does it take to complete something like that?

A: I suppose the construction took a year. But we worried over it for several years while we tried to make a decision to replace them.

Q: That has to be authorized, right?

A: Oh, yes.

Q: Authorized and approved?

A: That had to appear in the O&M [Operations and Maintenance] budget for the Corps of Engineers for major replacements. It's a replacement item, but the money definitely has to be authorized.

Q: But normally those aren't any problem, getting the money for that kind of replacement?

A: Oh, yes, it sure is.

Q: Is it? Did the Corps or Congress give you some trouble on that?

A: Not Congress. The Corps has to decide to prioritize the items that they wanted. When that money goes for that purpose, it doesn't go for some other purpose. There was no clear finding that the penstock was going burst. It was just that we felt that would be prudent because there was a potential for a problem.

Q: So you had to fight that one through OCE?

A: Well, we didn't have much trouble convincing OCE, but it took several years to get the authorization through. In other words, we didn't feel there was impending failure. If we had, we would have done something very quickly or we wouldn't have used the power units.

Q: Yes, just shut it down then?

A: That's our fallback, you know. If there's a bad leak or there's a bad deflection, we just shut the unit off, lower the gates and don't use it until we get it fixed.

Second Powerhouse at Fort Peck Dam

Q: Have you had any other replacements up there on the other dams?

A: Oh, yes. There have been several replacements over the years. There were originally three flood control tunnels at Fort Peck intended for making releases separate from the power plant or the spillway. About 1950 it was decided to construct a second powerhouse at Fort Peck and to convert one of the flood control tunnels to a power tunnel to feed the new turbines.

Q: When you put a new powerhouse in, is that what you did?

A: Yes, we built a second, entirely separate powerhouse

Q: So you had to go in and actually put the powerhouse, the penstock, and all of the other things in there, the turbines and such?

A: Oh, yes. I'm sure they anticipated that when they laid out the project. At the downstream end of the tunnel they added a bifurcation and two free-standing steel penstocks that fed the two turbine units. The new powerhouse had its own surge tank.

Q: So that's a major, major, undertaking.

A: It was a major construction project in itself, the second powerhouse at Fort Peck.

Q: How about at Garrison or Fort Randall or Oahe? Did they have any problem with those? Any replacements there?

A: No, you mean in the power tunnels?

Q: Yes.

A: Not that I know of. There were just the usual concerns, but as far as I know we had no major replacements and we had none of that kind of a problem.

Changes in the Fort Randall Design

There was a fairly late change in plans for Randall, however. There are eight tunnels. Originally they were going to have four flood control tunnels and four power tunnels, They planned in the future to convert two of the flood control tunnels into power units. But after construction had just gotten underway they decided to do this right away, so all six power units were put in at the very beginning, leaving two flood control tunnels.

Q: Now that was done without any problem?

A: No, it wasn't any problem because the construction planning was very carefully done with this in mind. Space had been left for it in the powerhouse, and it essentially became a continuation of the construction of the dam.

Q: Well, what I meant was did it present any problem with the flood control?

A: No, we had the remaining flood control tunnels plus the gated spillway which were adequate.

Q: So this was really taking advantage of a situation to increase the hydropower output?

A: That's right. The reason the two extra tunnels were put in was so they would serve as future power penstocks. They did not really need them from the very beginning.

Q: So that's just careful engineering?

A: That's just careful planning which is part of good engineering.

Q: Yes, looking forward to the future potential, realizing it's a lot easier to put it in the first place than go back and retrofit it.

A: That's correct.

Q: Are there any other things about the mainstem dams that you recall that were really prominent as far as engineering innovations or problems that you faced?

A: I told you that the diversions were major engineering projects, major planning and engineering projects.

Q: Right.

A: I think I talked to you about those the last time.

Sedimentation Studies and Wind Wave Protection in the Mainstem Reservoirs

Q: Right, you did. What about the subsequent operation of the reservoirs? How much were you involved in that? Your planning and reports branch had the section that did the reservoir theory.

A: Well, I was involved in the sedimentation aspects, how much sediment was accumulating in the pools and how much degradation, how much the tail water was falling downstream, and, therefore, how much the power head was changing, this sort of thing. I was involved in the wave protection. These are big lakes in a Great Plains region that is very windy. The wind generates six, seven, eight foot waves against the dam or against the bridge embankments up and down the reservoir.

Q: What kind of studies would you do in that case? Do you just take measurements, empirical observations and reports, to determine the wave aspects?

A: Well, for example, Gavins Point Dam is exposed to ten or fifteen miles of open water oriented more or less to the northwest. So you get the prevalent windstorm that you get up there, you get big waves against the face of the dam so you know how long the fetch is and how wide it is, because you know it's restricted on the side.

From maps we determine the fetch of open water in front of an exposed location, and the shape of the fetch. From analysis of years of wind records we obtain the frequency and durations of wind velocities from various directions. Then we use wave formulas to predict the size of waves that correspond to the fetch and wind velocity. Then we design embankment protection against the waves we have predicted.

We designed wave protection for dams, railroad and highway fills that crossed the reservoirs along the banks at critical areas like the marinas and recreation areas. Our protection was usually in the form of dumped or placed rock. For designing protection we came up with criteria for what size rock you need and how to design the riprap layer to withstand waves of a certain size.

One thing that our division engaged in, we went to the Coastal Engineering Research Center to study wave riprap design criteria. We used three of their wave tanks, including their great big wave tank that would generate about a four foot wave. We sent some of our own rock, the same kind of rock we planned to use for our wave protection, but a smaller size because we were looking at a model situation. We detailed one of our own engineers who stayed at CERC for two years running these tests. In the end we developed design criteria for sizing our rock protection. Our resident engineer was Arvid Thomsen. He did a great job and obtained valuable results.

Q: That was just for one of the dams or was that for all of them?

A: That was for any of them. Let's see, it was basically for, well, we had two places where we were having trouble. One of them was the Mobridge Railroad embankment across Oahe Reservoir and the embankment of the Snake Creek Sub-inpoundment in Garrison Reservoir. We used money for those projects as the source of funds for this research project. But we applied the design criteria every place, up and down, throughout the Missouri River basin.

Q: So you used it more than just in the reservoirs?

A: Oh, yes, we used it widely, wherever we had a problem with wind-wave protection.

Of course, we had other laboratory investigations where we were studying bank protection against stream velocities. In other words, when the river has a certain velocity up against the bank, what size rock do you need to protect the bank? We made other studies for that, too, over the years at the laboratory at Vicksburg, at Iowa University, and at our Mead Laboratory.

Q: So that was really for the stream bank protection?

A: That was stream bank protection. In the laboratory, we studied rock protection for both stream banks and for wind-wave protection for the reservoirs, two different purposes.

Q: Well, I want to come back to that question because I want to ask about flood control navigation later. But while we're talking about the reservoirs, I want to discuss the sedimentation studies.

Design and Construction of Large Earth Dams

A: You asked me a question earlier. I really didn't get going on it. What other engineering problems did the dams have? I do want to mention I wasn't involved directly in the geotechnical engineering, but these were earth dams on shale foundations of unprecedented height and proportions. The Corps was a world leader in building these first four dams on the Missouri River, which were Fort Peck, Fort Randall, Oahe, and Garrison.

At the time these dams were under study back in the '30's and the '40's, it was determined that shale foundations were so treacherous that you probably couldn't build any dams that are more than maybe 50 feet high. But Oahe and Garrison and Fort Peck are well over 200 feet high. So at the time they were built, we had three of the largest earth dams in the world. Since then the Russians, the Chinese, and so forth, all have built larger dams. But there were times in the '40's and '50's that we were pre-eminent and we had the largest earth dams in the world.

Soil Mechanics and Geotechnical Considerations

So these were earth structures of unprecedented proportions and much of the technology of constructing structures on clay shale was developed by the Missouri River Division between the geotechnical engineers and the Missouri River Division laboratory. Much of that technology was developed right here in the Missouri River Division and was applied worldwide. You can go to Tarbella over there in Pakistan or all over the world.

Q: What was the key to be able to do that?

A: Well, the key is understanding how clay shales behave. How they deform. How important it is to control water in the formation.

The Missouri River dams were built on the Pierre shale or the Bear Paw shale, they're very similar shale formations which are tricky because of the movements that could occur along the seams and joints. So the soil mechanics, the geotechnical engineering on shale foundations, had a major breakthrough in the Missouri River Division. Eventually, it was applied all over the world.

Q: Do you recall who the key people in doing that were?

A: Well, Ted Bennett was the geotechnical engineer in the division office. Spike Underwood, Stan Thorfinnson and Ed Galinsky in the Omaha District. Ed and Stan went with a major geotechnical engineering consulting firm, Woodward Clyde and Associates. Spike Underwood went to OCE.

Q: Now the dams are constantly monitored, I imagine.

A: Oh, yes. There are extensive monitoring programs at each project. Measurements are made and recorded regularly. Once the dams were constructed, they've never stopped monitoring them. This is one reason I'm a little concerned because our geotechnical organization, along with every other department in the Corps, is being depleted. We've got major tigers by the tail up there on the Missouri River, in my opinion. I don't know if we've still got the people that really understand these problems. I hope we do.

Q: The expertise you mean, experience?

A: The experience, yes. Anyway, several years ago there was some extra movement in one of the right abutments at Oahe and soon there were consultants coming from all parts of the country. This was a major concern for several years while they monitored and continually reported on the movements, and made measurements and so forth, before they decided it was just a superficial movement. It wasn't anything we needed to worry about. But that's just an example of what happens, periodically.

See, the water seeps very slowly into these abutments and foundations and so you can go for 100 years and then start having trouble someplace when water finally seeps into a Bentonite clay seam and lubricates it. Then movement may start within the shale. So it's important to keep watching these structures.

Q: I guess that's something a lot of people don't understand.

Construction Planning

A: Another aspect of engineering for the Missouri River Dam was construction planning which came to the fore as a discipline while these dams were being designed and constructed. No one dam was built by one contractor. There were dozens of contracts, always several underway at the same time. It was not easy to get them scheduled and get the one contractor working in an area where he won't be interfering with another contractor and to get the tunnel contractor through on time to do the diversion. Meanwhile, the embankment had to be gotten up so it was ready for diversion. Everything had to come out on a proper time schedule, so construction planning became a major discipline. In the Omaha District, Sid Price and Norm Gau were doing that, and their efforts contributed a lot to the construction effort.

Q: I imagine that just the planning aspect for the construction were certainly major contributions.

A: That's right.

Q: I was just going over Jake Douma's interview, as a matter of fact, and asked him about some of these dams. Of course, he knew all about them. He knew all of the design of them.

A: Yes, you bet.

Q: He crawled over a lot of them, he said. Well, are there any other things about the dams that you wanted to mention?

A: No. There are many, many subjects one could highlight about the design of these dams. We talked about some of the interesting ones: the tunnels, the power units, the penstocks, the surge tanks, and the embankments. I think we covered quite a few of the aspects. I don't think, well, I don't know if the structure, I don't think the hydraulics structures themselves were especially unique except at Fort Peck where they had these cylinder gates that were enclosed in an outer structure. It's pretty complicated.

Q: I'll have to get a book on Fort Peck and see.

A: Yes, I can get you one if you want one. The structures themselves, the spillways and outlet works, were fairly conventional. We tended to have radial gates, tainter gates, on our spillways in our projects, and vertical slide gates in the tunnels.

Tainter Gates

Q: What led to the decision on gate selection, the tainter gates, for example?

A: The tainter gate is made to order for the situation that we had there. It's not very heavy, relative to a slide gate, and more economical. It's good for regulating flows. Experience has shown they work very well on spillway crests of the type that we had. There is a problem in the winter time when ice forms on the tainter gates and there's a problem operating them. If we ever had to let a flood out when there's ice on the reservoir, we might have a problem. But, fortunately, floods don't usually occur under that condition.

Q: They're beneficial for you in that respect.

A: There are problems that we faced, perennial problems, on operating the tainter gates, ice damaging the seals, and all of this kind of thing.

Q: So is ice the biggest problem up there on the gates?

A: That's one problem.

Q: Okay. What other problems beyond ice do you have with the gates on the dams?

A: You're talking about tainter gates?

Q: Yes, or any kind of gates. I imagine they have a lifespan, too, that has to be looked at very carefully.

A: Well, yes, you've got to watch them very carefully. They're relatively light steel structures. Sometime over the forty or so years that all of these things were built, the design analysis of tainter gates has changed somewhat. In some of the older ones, they didn't properly take into account the trunion friction. You know, when you have to open the gate against the friction of the trunion.

You have to open the gate. The gate revolved around the trunion, you know, the pin on both sides there. Of course, when the water is pressing against it, there's a friction force that pushes the trunion against the bearing and so there's trunion friction. When you pull against that while opening the gate, that causes a resultant force that's not peripheral to the gate. It's not peripheral and not axial, so if the force wasn't properly designed for in some of the early tainter gates, there may be a problem.

Therefore, we asked the districts to check the design of all of their tainter gates to make sure they were okay relative to this problem. But if you want any details on the tainter gates, you really ought to ask Douma or Sam Powell when you talk to him. But if you really want to know about the tainter gate problems, I could put you in touch with someone that knows a lot more about them than I do.

Q: Okay.

A: I've just been around long enough to pretty much have an idea about what's involved. There were people who worked with me who were involved with this. I always tried to keep track of what was going on.

Q: Anything else with the mainstem dams that you can think of?

A: Well, of course, the sedimentation problem.

Q: I was going to get back to that one.

A: You'll get to that, maybe. The operation problems are without precedent also.

Computer Modeling and Management of Mainstem Reservoir Operations

Q: Well, you said that the earliest computers you had were to manage the reservoirs.

A: Yes, the earliest involvement with the Missouri River Division was a contract with the Raytheon Corporation to come up with a computer model to simulate the operation of these reservoirs. I don't think this initial effort was ever very successful. They never did really get the program going years later so it was really usable, so most of the operations up to the time we started operating the reservoirs, most of the so-called operation studies, were done by hand. Do you know want to know what an operation study is?

Q: What?

A: Well, you go back for as long a record as you can develop, like back to the 1880's on the Missouri River, and you develop the monthly stream flows for that time up until the time you're running the study. In other words, you've got a whole series of monthly stream flows for the Missouri and all the tributaries. Then you set up your reservoir system that you're studying. Then operate that reservoir system on paper for the whole period of record. That includes the major drought of the 1930's, and another one in the '50's, and some major flood periods. And then you see what you're operating criteria have to be to go through several years of drought and to take care of the major floods as they come along without causing major flooding downstream. They do these operating studies and on the basis of them they decide what operating rules they're going to have for the reservoirs.

Q: So those studies determine how much they're going to keep or impound on the reservoir and how much they're going to release?

A: Yes, these reservoirs have a great storage volume. There is over 70 million acre feet of storage in the reservoir system on the Missouri River. The annual flow of the Missouri River at Sioux City was about 24 million acre feet. The storage is about three times the annual flow of the river. Of course, the Missouri River is a major river, so relative to the annual runoff we have a large amount of storage. We have three of the largest reservoirs in the world, in terms of how much water they store. Fort Peck, and Oahe, and Garrison all have about 20 million acre feet.

So you've got a major control of the river at Sioux City. What they do is they catch the spring and summer floods and then hold on to them, and they let them out all summer and all winter. One of the purposes for letting the water out is to maintain enough flow in the river for navigation and to generate power. So they let the water out all of the rest of the year and then by March, they get back down to what they call the base of flood control. Then they start over again. They take a whole year to let the water out.

If they've gone through a period of drought, the base of the flood control is high enough so that you could go through a major drought, like the drought of the '30's, and you've drawn down the reservoirs quite a bit, but you have enough water to serve most of your purposes throughout the drought. Of course, at the end of one of those periods, the reservoir system is way below the base of flood control. Then it may take several years of normal water supply before the reservoirs fill up again.

Q: You just keep more each year?

A: Right. Now we've gone through a period of several years where the water levels are brimming over. They've been at the base of flood control every year. The problem has not been to have a carry over storage for a drought period, the problem is to get rid of the water early enough to be ready for the next flood the next year.

Q: When you have years like that though, doesn't that present a problem downstream for things like stream bank erosion and the channel?

A: That's a special problem. Right now, we're letting out twice as much water as we usually do this time of year, We usually let out around 30,000 cfs from Gavins Point. Now they're letting close to 60,000 out because they've got to evacuate all of this flood control storage. They're sitting on it because on downstream there are rains, and they don't want to contribute to the flooding downstream, so they wait until it looks like the rains have subsided and they let the water out. So now this is the period that you want to let the water out. Of course, it's still the rainy season, so if they see rains developing, they'll probably shut the outflows off for a while.

So right now, because the reservoirs are so high, we're letting out twice as much water as we usually do, almost twice as much. That poses special problems along the way. There are bank erosion problems, of course, and then there are problems at water intakes for cities. People raise hell when they have docks and marinas along the way and the river is higher than it usually is. They raise almost as much hell when it's lower than it usually is. You're right. It does pose special problems downstream.

Q: When you design your flood control and bank erosion projects, you take all of this into consideration, including that you may have these higher than average flows.

A: Right. After the '50's, we tried to take all of this into consideration, but we could not predict the magnitude of all of the problems.

Q: Well, that's largely because of the lack of a long statistical basis to work from, isn't it?

A: Well, also the lack of insight. We didn't attach the importance to certain things, certain phenomena, at the time. Then they became quite important.

Degradation of the Missouri River below Gavins Point

For example, in general, the river is degrading below Gavins Point. So at Sioux City, which is the head of navigation, the water is maybe nine feet lower than it was 40 years ago. So there's no problem there with flooding, or drainage, or anything, between Sioux City and Omaha. But between Omaha and down into Kansas, in years like this year when there's an abnormal amount of water being released in late spring and summer, the river is so high that the farmers in the adjacent fields can't drain the rainwater out of the fields. The culverts through the levees are not free draining because of the high river and there are few pumps. So a year like this year, the farmers' fields, those that are adjacent to the river, are going to be swamped almost all year. They couldn't get their crops in and if they had them in, they'd be drowned out every time it rained. So this is causing a problem we didn't properly anticipate.

Q: And those are the most fertile fields they have, too, probably, and the most productive.

A: Yes. In a normal year, of course, there's no problem. And furthermore, they were protected from all the river floods that would have occurred without the dams. But in the year when the river is high all summer, they can't properly drain the fields. Without pumps to pump the water out, they can't do that. It would take an awful lot of pumping capacity. That's one of the problems.

The problem was exacerbated by the fact that we created a navigation project. We contracted the river quite a bit, made it deeper for navigation. I mentioned that the river has degraded from Sioux City downstream to about Omaha, so there are no flooding or drainage problems there. Most of this degradation is the result of our contracting the river channel for navigation, starting with the head of navigation at

Sioux City. Only a minor amount of degradation at Sioux City can be attributed to degradation below Gavins Point Dam. But in the one stretch I mentioned, from Omaha down into Kansas, the navigation project has raised the stages in the river for the smaller flows. And so it makes it all of the more complicated when we let out an unusual amount of water for a long periods of time like we are right now, say 60,000 cubic feet per second compared to the usual 35,000. Then the farmers develop this problem.

Q: Is that because of the channelization that was done and taking out the horseshoe bends?

A: That's because of the channelization. It's a localized problem. It doesn't happen all of the way down the river, but it does happen in about a 100-mile stretch below the mouth of the Platte River near Omaha.

Q: South of St. Joseph?

A: Possibly.

Q: Down to Leavenworth?

A: No, to St. Joseph, maybe. Below that, they don't have those problems. The farmers are raising hell with us because of drainage in years like this one.

Natural and Artifical Cutoffs

Q: Yes. I was going to ask you about the cutoffs of the Missouri's horseshoe bends, where you took all of the horseshoe loops out.

A: Oh, we didn't take them all out.

Q: Well, you took some of them out.

A: We took a lot of them out. Actually, we made a few real major horseshoe cutoffs. Most of those were made in the '30's, at least along the Missouri River. But we did make a major cutoff of Liberty Bend below in Kansas City in the 1950's.

Then in Omaha, in the Omaha District, above Omaha, we cut off Desoto Bend. It was eight miles around, and we made a cutoff of about two and a half miles across the neck.

Q: That's the one out by Eppley Airport, isn't it?

A: No, that's Carter Lake. That was a natural cutoff. That happened during a flood around 1880.

Another one, you may remember, across from Offutt, Lake Manawa, over in Iowa. This was another of these natural cutoffs. Then, if you fly over the Missouri River Valley, go up to Sioux City or down south, you'll see all over the valley's bottom, the scrolls of old Missouri River channels that have been formed and cut off naturally by the river over a period of hundreds of years.

Well, usually what happens in the normal course of events, if there is no human intervention, as the floods come over the years, the lake just silts up and goes out of business. All that you see from the air are the scrolls where the lakes have been, but they're filled up.

Q: Right.

A: But Carter Lake was right near the city, and so is Lake Manawa, and the river got leveed and we kept the floods out, so that maintained the lake. But those were natural cutoffs.

In 1960 we made an artificial cutoff at Desoto Bend, which is up near Blair, Nebraska, where we cut off probably five miles of river. It was eight miles around, and we converted it to two and a half miles across the neck. Then we purposely built levees to keep the flood waters out of there. That's now the Desoto Bend Fish and Wildlife Preserve managed by the U.S. Fish and Wildlife Service. In the summertime, it's open for recreation. That's where millions of snow geese come in every November. You've probably heard about it.

Now, we made other minor cutoffs. In regularizing the course of the river into gentle curves for navigation, we sometimes left old channels to the side. We cut them off, all right, in the process of regularizing the river, but we haven't shortened it that much. We left the old channels to the side in the interest of preserving some of the riverine environment.

The kind of cutoff you were thinking about, the horseshoe bends, that would be Desoto Bend and Liberty Bend, and then St. Mary's Bend, which is down just opposite of Offutt. But that St. Mary's Bend cutoff was made back in the early '40's, before my time.

Q: So not a lot of that has been done lately?

A: No. In terms of the total length, the total 700-mile length of the navigation project, it's not that much. It's less than 10 percent.

They're interesting operations. I was involved in the Desoto Bend cutoff where the objective was to preserve the lake. It was a new objective for the Corps. Previously, they cut them off in such a way they purposely let the river bring sediment in to fill up the old channel. The idea was to reclaim land for farming. But here we had to save the cutoff lake. Actually, the Fish and Wildlife people were paying for it, or at least paying us to do it in such a way that it would not be filled up. It would be retained as a lake, so the operation was designed with that objective.

Q: That must be one of the times the Fish and Wildlife Service was cooperative.

A: Oh, they were pretty cooperative.

Q: Were they?

A: They were certainly very cooperative in that era. Next time you ever come near Omaha, you've got to go to Desoto Bend because it's a great public attraction. And they uncovered a river boat, the *Bertrand*, that went down in 1866.

Q: Oh, that's right, sure. I remember that, right.

A: Well, anyway, there's a museum there now, a good visitors' center. The museum has all of the goods that they removed from the *Bertrand*, and cleaned up. These goods were destined for the mining fields of Montana. Everything you can think of, needles and thread, jars of pickles, guns and bullets, and shovels and picks, and clothing and hats, and shoes, you name it.

Q: It was all there.

A: They're all on display there. It's really quite interesting, of historical interest.

Q: I remember that was sort of being dug up when I was there in the early '70's.

A: Yes, these guys who found it, they expected to find some carboys of mercury. But they didn't find any mercury. Then, of course, the government stepped in and said, "That's great. Thank you for finding this, but all of this stuff is ours." So they did pay them a fee for the salvaging. They got the joy and satisfaction of doing the salvaging.

Q: But they didn't strike the motherload they thought they were going to get?

A: Even if they found the stuff, probably the government wouldn't let them keep it.

Q: The government takes, what is it, 95 percent of everything.

A: Something like that.

Degradation and Reregulation of Flows on the Missouri River

Q: Earlier you mentioned the sediment issues.

A: Yes.

Q: Let's go back to that because that's really your specialty.

A: That was supposedly my specialty.

Q: That's exactly what you were originally hired to do--to study sedimentation on those reservoirs. What kind of concerns or plans do you have to make to handle sedimentation?

A: Well, you have to look downstream from the dam, and you have to look upstream from the dam. Downstream, I think I mentioned about the concern with degradation.

Then there are many environmental changes that go along with degradation. You now may have degradation, but we came to realize after many years that the reregulation of the flows is a major factor in how the river changes its nature.

In other words, in the natural condition, you got floods almost every year over the banks. With dams regulating the flow, you go for years and years and years with the water just within banks, at various levels within banks. Even this, when I said today that we were releasing 60,000 [cfs] out of Gavins Point up there, all of this is within banks. Without the dams, this year a great flood would have flooded the valley. So you've got the effect of reregulation, and they've got degradation and the effect of reregulation of flow.

A good example of what you can get into with reregulation is the stretch of river below Gavins Point. The bank caving continues. You've still got water in the channel. The banks are sandy. The river is not controlled, at least between Sioux City and Gavins. The river was still what we called wild. It still meanders between banks, and it erodes some banks and deposits sandbars elsewhere. This is just as in the natural river.

Every year the natural river was changing its channel. Actually, the river was in multiple channels. One, two, or three channels over a width of maybe half a mile. One year the main channel might be on the right side. Another year the main channel might be on the left side. It was typical of an alluvial river channel. What happened in nature was that the high banks were always about the same width apart because you had all of this going on between the high banks. If it eroded the high banks in one location, you'd get floods that deposit sand to create high sandy areas elsewhere. The result was that the sandy river channels would always be about the same width, with the same vegetation and trees in the adjacent high ground. Of course, the natural channel would continue to shift its location and in 100 years might be on the other side of the valley.

But once you regulate the flows, there are no more floods to deposit sand over the banks and create new high sand bar areas. Now when you erode the high bank, that's permanent, so this sandy area with the multiple channels I'm describing gets wider and wider over the years. There is a permanent loss of high banks because there are no floods to heal, redeposit material at the high bank elevations. And, of course, the channel degradation means that the water level tends to drop because the sand bed is eroded out. This only happens fairly slowly.

Another effect of flow regulation is at the mouth of the Niobrara River. Have you heard about that?

Q: No.

A: Do you know where the Niobrara is?

Problems with the Delta of the Niobrara River

Q: Yes, it's pretty far up north of Omaha.

A: It comes in just above the headwaters of Gavins Point Reservoir. Then, another 30 miles upstream is Fort Randall Dam. Lewis and Clark described a great sandbar at the mouth of the Niobrara River in their diary. The Niobrara River is a relatively steep stream that puts coarse sand out into the Missouri River. The Missouri River has fine sand, and so the Niobrara puts this delta of fairly coarse sand into the Missouri River.

What happened in the natural condition was that every few years, the Missouri River would come up with a really big flood, maybe 200-250,000 cubic feet a second. That would tend to wash this coarse delta downstream. But once we started regulating the flow at Fort Randall-- I don't think we ever released more that 60-70,000 [cfs] since we closed Fort Randall in 1952-- there are no more of these flushing flows from Fort Randall. That meant that this Niobrara delta just accumulates and accumulates.

The result is that both the Niobrara River and the Missouri River are aggrading because the delta in the Missouri at the mouth of the Niobrara is building up and so the water levels upstream on both rivers are rising. Eventually, we relocated the town of Niobrara, which is located right in the junction of the two rivers.

Q: I remember that

A: Now, the Niobrara relocation was financed by Gavins Point Dam funds. But, actually, this is really above the Gavins Point head waters and aggradation from Gavins Point pool was not a major factor. It was the Niobrara River delta that was the culprit. Actually, Fort Randall funds should have paid the bill. It was the flow regulation at Fort Randall that was causing the problem. But that's an example of what you can get into with flow regulation.

Q: What's the solution to that particular problem of the Niobrara?

A: Well, we relocated the town of Niobrara.

Q: I know, but sometime that problem is going to have to be solved, isn't it?

A: We relocated Niobrara State Park that was right there, too. There's really no way, physically, to avoid it. No good way.

Q: You'd actually physically have to take the delta out of there, wouldn't you?

A: Yes. We would be talking about a very large amount of sand. It's not feasible, and once you took it out, where would you put it?

Q: In the long run, what is going to happen if it keeps up building that sand?

A: The delta is going to continue to aggrade on the Niobrara. Meanwhile, it pushes the Missouri River over to the other side. Eventually, aggradation in the Gavins Point headwaters will add its effect, so it's going to be a continually aggrading situation. Just as the Mississippi at New Orleans is a continual situation.

Q: Yes, that's what I was sort of thinking about when you talked about this because I was thinking about the whole controversy of the 19th century on how do you keep the Mississippi from silting up? Eads put in all of the jetties to keep the water channelized and flowing, and flushing the entrance to the Mississippi out. I was thinking that sounds like this kind of situation.

A: Yes. Well, we've got these jetties that take the Mississippi River out where it dumps its sediment load into this a very deep canyon in the bottom of the Gulf of Mexico. The Mississippi River bed at the mouth doesn't build up. I don't know what it would take to fill this canyon up.

Q: The Mississippi keeps on spreading that delta, though, gets larger and larger, doesn't it?

A: Well, that's just it. The flows are going into this canyon. Where it used to spread in the currents, with the wind and currents taking it to the west and to the east along the coast. That's why the coastline is receding on both sides of the Mississippi River because of the reduction in Mississippi sediment that is dispersed along the coast, and that's one reason the shrimp beds are being washed away.

Q: Because they don't have that mud to work in?

A: That's right. That's a problem down there. The Mississippi is an example. In our bailiwick, it's the Niobrara River delta that's the problem. The reason the Niobrara is a major problem for us is that it has this coarse sediment. And, of course, the Platte River below Omaha also has sediment that is much coarser than the Missouri. That's probably one of the reasons the stages for the channel flows on the Missouri have risen in the reach downstream from the Platte River.

The Platte River

Q: The Platte, I don't know, my view of the Platte River, from the times I've seen it, it doesn't have a heck of a lot of water in it most of the time.

A: Well, sometimes.

Q: Well, I know that sometimes it does.

A: It has a good-size flood every few years, as in 1993 when it put 253,000 cubic feet a second out into the Missouri River. So it may be a mile wide and an inch deep some summer day, but it's not always like that. I've canoed down the Platte. It's very pleasant, but it does have its floods. They occur only every few years.

Q: More infrequently.

A: That's correct.

Q: But it is a good size river?

A: Yes, it is.

Q: I mean it's relatively wide.

A: It's about a half a mile wide.

Q: It also meanders all over the place.

A: On a summer day, you probably could wade across. Well, you might be surprised when you hit certain places. You could almost wade across. It falls several feet to the mile, so the current is quite swift through there.

Q: Well, everything up there falls quite markedly, though, doesn't it, from the Rockies down?

A: Well, of course, the Missouri is less than a foot a mile. Then these tributaries are often steeper. They come right into the Missouri.

Sedimentation Issues

Q: Well, let's go back to the sedimentation issue, the sedimentation question. When you're regulating the reservoirs. . .

A: Well, I talked about sedimentation relative to flow regulation and degradation.

Q: Right.

A: Now, go ask your question. We haven't talked about the reservoir yet.

Q: Because the reservoir collects all of the silt, right?

A: Now, the reservoir, our reservoirs, anyway, essentially collect anything that comes in. It's both fine material, both the sand from the river bed upstream, and the fine material, the silts and the clay that come in. In the Missouri, in the natural condition, most of the sediment, maybe 80 percent of the sediment, is silt and clay. It's fine material. Maybe 20 percent is sand, the coarser material that you find on the bed. But it's fine sand that makes up the bed of the river. But in the suspended sediment load, maybe only 20 percent of it is fine sand. The rest of the sediment load is very fine material, the silts and the clays.

Depending on the size of the sediment particles, they deposit in different ways. The coarser sediment, the sands, deposit in the reservoir headwaters where the river velocity is first retarded. The sand deposits aggrade the channel, raise the water surface and projects the reservoir backwater effect slowly upstream.

Some of the fine particles of silt and clay remain as discreet particles move farther into the reservoir in suspension until they encounter velocities so low that they deposit. Then there are some of the clays in suspension that tend to flocculate or coagulate into large clumps that settle to the bottom near the upper end of the pool. On the bottom the flocculated clays form a thick soupy liquid that flows along the bottom toward the dam. It eventually reaches a stable configuration and comes to rest and starts consolidating. The flocculation I just described occurs when a certain class of clay-shale particles encounters water with a certain concentration of salts. These conditions are met in the Missouri River Reservoirs. We have sampled this newly deposited soup or "thixotropic" liquid and found dry densities of one or two pounds per cubic foot [pcf]. After the material has consolidated in place for several years, we have observed densities of 20 or 30 pcf.

Q: Now, what are the consequences of these things for the reservoir?

A: Well, the sand deposits in the headwaters aggrade the river channel and cause the reservoir backwater effect to progress upstream. Over time the upstream progression of high water surfaces might threaten problem water intakes, flood protection, drainage systems, swamping of land, and ice in winter.

A large portion of the incoming sediment load ends up in the bottoms of the reservoirs and occupies what we call dead storage. So although it occupies some reservoir storage it will be hundreds of years before it really begins to interfere with the operation of the project. Of course, it probably does affect the fishery.

So far, with the possible exception of Gavins Point, there have not been significant deposits in the reservoir above the base of flood control. The flood control function has not yet been affected. Although there has been some deposition in the middle levels of the pools, the volume of the deposits has been small compared with the very large conservation storage that was designed into the systems. So our carry over capacity has not been seriously impaired. At Gavins Point the sand deposits upstream at high elevations have depleted the flood control storage. Eventually, the depletion of flood control storage at Gavins Point might be a problem because it would diminish the capability of Gavins Point to control floods from the Niobrara and Verdigris Rivers.

Q: Yes, I imagine. The fish like to stay on the bottom.

A: As far as the states are concerned, these should be fishing projects aside from every other purpose.

Q: The recreation aspect is jeopardized by this?

A: I think so.

Q: Mainly because it affects the breeding grounds for the fish and bottom feeding?

A: Yes, and because it affects the benthic organisms that feed the critters at the bottom of the food chain. It's really inevitable because the river is, as I mentioned before, between these bluffs on both sides, these chalk and shale bluffs. A significant amount of sediment is put into the water by the wave erosion against these bluffs. This may be a predominant source of sediment deposition in the downstream ends of the pools. The wind keeps the reservoirs turbid because the waves are almost continually washing against the bluffs and the material is coming off into suspension.

Q: So the reservoirs are getting wider but shallower?

A: A little bit wider, and a little bit shallower, and never clear because the action on the bluffs keeps adding fine material to the water.

Q: Well, that's always the thing about these alluvial rivers--they're always dirty looking because they carry so much sediment with them.

A: One of our jobs was to predict the aggradation at the headwaters. For example, at Williston in the headwaters of Garrison Reservoir, at the time that the Garrison Dam was constructed, we built levees around Williston to compensate for the expected aggradation, so we're constantly watching that. And, I think, there's been one project now to raise the levees at Garrison, at Williston, because the aggradation is developing.

Q: So these are the things that come in train with the reservoir that have to be watched all of the time?

A: That's correct. There's a continuing sedimentation observation program. Certain ranges are surveyed every five years or so and analyzed to see how we're doing, to see how the water levels are changing and so forth. It started out with surveys almost every year, but it was not necessary to do it that often.

Q: Does the sediment branch still send out those teams you talked about before to do that or are they just all staged out of Omaha District now rather than being out at the dams?

A: It's all done by contract now. We don't have any field crews anymore, which is a pity. We have very few individuals that even know what the reservoirs look like. They don't get up into them.

Q: Is that right?

A: The contractor goes up and surveys them.

Reservoir Operations

Q: How many people do they have operating them now, operating the reservoirs?

A: How many people?

Q: Yes. Do they still have people at the reservoirs, a few of them, I imagine?

A: Oh, yes, there's a staff at each project.

Q: Oh, of course, they have power.

A: I think the person in charge of the project now is the recreation guy, the resource manager. That's quite a bone of contention, you know. You'd think when you have one of the major dams in the world, you ought to have an engineer there in charge of the dam.

Q: You'd think so, especially if they have big power units in them.

A: Yes. But there is a separate superintendent of the powerhouse. That's quite a controversy. We always felt it should be an engineer who's in charge. But I think in more and more cases now we're getting the cultural resource management type people.

Q: The cultural resources, yes. It's sort of interesting that something that was a throw-in becomes the primary consideration.

A: That's right.

Benefit-Cost Calculations

Q: I mean the recreation benefits were sort of add-ons, weren't they?

A: Well, recreation wasn't even a purpose at the time that I started in. Then Congress made that a purpose. That evolved over the years.

Q: You couldn't use it in benefit-cost analysis, could you?

A: I don't believe so, not until the 1950's. Of course, they didn't worry about cost-benefit when they built this project. It was authorized back in the '40's and it was "unquestionably justified," according to what the Chief of Engineers said. That's what he said, and that's the basis on which we built it.

Q: The Chief of Engineers used to be able to make those decisions, didn't he?

A: I think it was justified. The construction has been paid for by the power revenues alone, already.

Q: For all of them, except for the ones that don't have power, I guess, and then the other benefits derive from that.

A: I mean without even considering the benefit that you could figure on paper, you can look at the sales of power, a return of dollars and cents. You don't receive the flood control benefit in terms of regular payments of dollars and cents. No one realizes the floods that we did not experience down here in Omaha since 1952.

Q: Because of the dams?

A: But the benefits have been substantial. The project has paid for itself more than once over in terms of flood control and power.

Environmental Changes in the Missouri River's Regimen

Q: We've talked about some of the sedimentation problems. I think we largely finished that up. Did you have any other comments that you wanted to make about that particular aspect, because you spent so much of your career doing it?

A: Well, I think maybe the important thing we found out was that between the flow regulation and the dams, the stopping the sediment, the entire regimen of the river downstream changed. The river regulation, in combination with the channelization structures and the bank protection structures for the navigation project, more or less converted the river from the natural river with multiple channels and wooded areas on the sides, and channel shifting in location, to essentially a canal that ran from Sioux City down to St. Louis. There was a major transformation in the nature of the Missouri River. It, of course, brought many important environmental questions.

Q: Did you get much involved with those particular aspects, the environmental questions, either in the district or in division?

A: Oh, yes, trying to explain what was happening. Mostly to explain that we put the wheels in motion in the 1930's when the Congress authorized the navigation project. Now it's pretty hard to convert the river back to a wild river because it's already been tied down and converted into a channelized river. But we've had several different projects or efforts to preserve the remaining natural habitat, as much as possible, adjacent to the navigation channel--in other words, to keep certain chutes open, not force them to silt up.

Originally, the idea was to reclaim all of that land, the wide swath of sandy river channel that the river was occupying and shifting around in. We did reclaim the hundreds of thousands of acres between Sioux City and the mouth. Farmers are farming land now that they would never have been able to farm back in the '30's or '40's because of the shifting river and frequent flooding. In tying the river down, we've created farmlands where there was just river channel before.

But the Fish and Wildlife people, the environmental people, see this as a great damage to the environment of the river system. That's pretty much what the Corps is faced with all over the country. There's an incompatibility between dams, river rectification, levees, and flood control works on one hand, and the maintenance of a natural stream on the other. The Corps has become more and more active in trying to reach a happy medium. We've seen the light, and we've spent a lot of time doing that.

But there's been a major transformation of the Missouri River, and we just can't deny it. We've spent a lot of effort in later years in that controversy, in interaction with the Fish and Wildlife Service and with the environmental act, NEPA [National Environmental Policy Act].

Effect of the National Environmental Policy Act (NEPA)

Q: How much does that change the way you did business?

A: For example, it might have a major effect on how we operate the reservoirs. You know, we're not going to be free to generate power as we would like to in order to maximize revenues. The Endangered Species Act has reared its head. There are a couple of birds that nest on the sandbars that are adjacent to the river. They like sandy rivers and they're on the Platte, but they're also on the Missouri from Gavins Point down to Sioux City. There's the Least Tern and there's the Piping Plover.

Those birds, at least the Plover, likes to lay its eggs right out in the open, right on the sandbar in the middle of the river. It's partly so he can see predators coming, but that's just their instinct. These eggs are out there and fledglings are being hatched. Meanwhile, if we have a year like this year where we have to come up with the discharges to empty the system, the higher discharges inundate the sandbars, or at least reduce the areas of them, tremendously. That affects the breeding of the bird.

Also, we're not free to be unrestrained in generating power from our hydropower plants. We've got to restrict the discharge. In normal years, we have to restrict the discharges from Gavins Point during the nesting season such that we keep a certain acreage of sandbars out of the water so that the birds can hatch. The result is we've had our operations people wandering downstream by boat, wandering out on sandbars, looking for Plovers, and counting Plover eggs.

This could have a major impact on whether we maximize the revenues from generating power from our system. We're restricted in generation in the summertime when there's a big air conditioning load in the Middle West because of this environmental factor. This is just one example.

They're hashing that over now. There's a master plan operating the Missouri River that's being revised and restudied. I don't know whether they'll ever adopt a new plan or not, but that's what's going on right now, trying to reach a happy medium between the needs to operate the river for the original purposes of the project, and the need to do as little environmental damage as possible. The endangered species are a particularly potent factor in causing us to restrict how we might want to do business.

Q: Did NEPA provide any problems? I know it provided a lot of problems for your major construction projects on the river?

A: Oh, yes. For a while there, the Bald Eagle was on the list of threatened species. Now, there's the Northern race of Bald Eagles and the Southern race. Incidentally, as far as I was told, no ornithologist can tell the difference. But the Southern Race is not threatened, but the Northern Race is. The Bald Eagles nest along the Missouri River. You go up there in the very early spring, from Omaha up to Sioux City, and on up to Yankton, you can see the eagles perched on the piling along the side of the river. They nest in trees along the river.

The result is that when we file an environmental impact statement for a construction project along the river, putting in a dike or installing a revetment, we had to assess the possible location of Bald Eagle nests, and we have to restrict the construction activities to the season when it's not the nesting season for the eagles. For example, right below Fort Randall Dam we had a new operations building planned in the tail waters of the dam, right on the downstream berm of the dam. Essentially, we resited it because there was an old dead tree there and the eagles had a nest in it or used it as a perch while they fished in the tail race. So the Corps resited the building just for that factor.

To get on with your question, yes, it does interfere with construction. We have to file an environmental assessment every time we let another construction contract. That's part of the process, the environmental assessment of the effects that the construction might have.

Q: Has that killed any projects or just made you change them, or move them, or delay them?

A: Well, it probably has killed some projects, new projects, that were in the embryonic stage. For example, it will be a very cold day in hell when the Corps builds another reservoir any place because of the environmental impacts. That's pretty much killed the dam building business. Although I think maybe we already have built most of the good projects. We may have overbuilt where dams are concerned.

Q: Well, Vern Hagen told me that there are just so many places you can build a dam.

A: That's right.

Q: And so many dams that you really need.

A: But now that we're deeply in the recreation business, also. Of course, we're not worrying about storing huge amounts of flow for flood control. Maybe the recreation lake has become more and more popular, and there's more and more of those that might be justified. Although, it's kind of questionable that the Corps will be the one to build them.

Flood Control Reservoir System in the Omaha Area

Q: Yes, that would likely be the Soil Conservation Service?

A: Well, or just local, states, Natural Resource Districts, and so forth. We've got several lakes around Omaha that are strictly recreation lakes. I mean they were justified for flood control, but the people in Omaha consider them recreation lakes. That's really their big justification. That's how they got the public support to go ahead and build them.

Q: But they were built as part of the overall flood control plan for the Missouri.

A: No. They were built as part of a local flood control plan for the Papillion Creek watershed in Omaha. We had, oh, I don't know how many dams. We had maybe 20 dams planned. We've only constructed four of them, four out of the 20, mostly because in this area there is big opposition to building dams, period, aside from the environmental issue. If you do land treatment, you catch the water where it falls, and you don't have to build a big reservoir, and so forth. Of course, hydrologically, that's a fallacy. You can't catch enough water to really accomplish the kind of flood control we were after.

A lot of these dams didn't get built, just because of opposition. This is over and beyond the environmental issues. It had to do with taking farmlands to build reservoirs.

Q: That's always a problem.

A: Yes. So we built four out of 20 around the Omaha area. Those which we built are not exceptionally potent flood control wise, but they're very popular recreation lakes. We were able to justify them, economically, by the recreation benefits.

Q: Now, those are Standing Bear . . .

A: Yes. Okay. Standing Bear and Cunningham Lake north of Omaha, and Wehrspan Lake and Zorinsky Lake near Millard. I don't know whether you remember those or not. They were probably built after your time here in Omaha. They're very good recreation lakes, and they could do a lot of flood control except that there's not much downstream to protect. People in Omaha are learning to stay out of flood plains. Flood plain zoning is really accomplishing the objective of reducing flood damages.

Q: They're not building in the flood plain as much as they used to.

A: Nebraska has a series of Natural Resources Districts, and they can set up almost every stream with flood plain zoning. You cannot construct anything within what's defined as the floodway. Inside the 100-year floodline, you're very restricted as to what you can construct, so that's been quite successful in reducing the flood hazard, at least the flood damages. But, at the same time, it's been effective in making unnecessary some flood control projects.

Flood Control Projects

Q: Let's talk about that whole issue of flood control because a lot of your work must have focused on that.

A: That's right.

Q: We've mainly talked about the river, but we haven't talked about some of the flood control and the navigation projects that were done on the river itself and on the tributaries.

A: We worked on a lot of the tributary streams on what we called local protection projects.

Q: Do you want to talk about those? What were the most significant ones that you worked on?

A: Well, while I was in the division office, they finished up quite a series of dams. I was mostly in a review capacity. You've heard of Tuttle Creek, Perry, Milford in the Kansas Basin, or Pomona, Stockton, Harry S Truman, and Hilldale in the Osage Basin. There were also Chatfield and Bear Creek near Denver, Bowman-Haley on the Grand River in South Dakota, Hillsdale and Blue Springs near Kansas City, the four small dams on Papillon Creek Basin near Omaha, and seven small dams in the Salt Creek Basin near Lincoln, Nebraska. There are others I do not recall at the moment. There are a lot of small- and medium-sized reservoir projects that were done in the last 25 years, say between 1965-1990.

Then we had an important job up in Sioux Falls, South Dakota. The river flows around the town in a horseshoe shape. We took the excess flood flows, allowed certain flows to go down around town, but then we diverted the excess flood flows across the narrow neck upstream from town, and put it over a spillway down a 100-foot cliff, and let it into the river downstream from town. I thought that was an interesting project. It's worked, and it saved the city a lot of flooding since we constructed it in the 1960's. There are a lot of projects that are just levee systems on smaller creeks, and, of course, along the Missouri River, itself.

Q: They are used to contain the flooding?

A: Yes, just build a levee and contain the flood between the levees.

Q: I imagine that the options that were looked at early on, in the '50's and '60's, were mostly structural solutions.

A: Yes, and then more and more, according to the new rules we operated under, we were required to consider alternative plans for reducing flood damages. We had to consider flood plain zoning, and relocation, and flood proofing, in addition to what we called structural flood control measures. By structural, I mean not just concrete structures, but any construction including levees or channels. According to the rule, we had to consider thoroughly these alternatives.

Q: What would you say is the relative proportion of the non-structural to the structural projects? How much did that change over time when you were there?

A: Well, at first we didn't even worry about it, back in the '50's and early '60's. Then, by the time you got to the '70's and the '80's, almost every project had its non-structural aspects.

Q: So there was some aspect of virtually every flood control project in which you used non-structural solutions?

A: Oh, yes. There was zoning and flood warning systems. The act that required us to consider these alternatives was a good one. Maybe all of the latter projects had a flood warning aspect, a flood plain zoning aspect, and so forth, in conjunction with the structural project.

Flood Protection in Major Urban Areas

Q: What were the largest of the local protection flood control projects that you were involved with?

A: The levees and flood walls in the urban areas around Kansas City, Omaha, and St. Joe, those might have been the largest projects. But the one I mentioned at Sioux Falls was a large project, and also the Floyd River at Sioux City, and the Brush Creek, Blue River, and Kansas River projects at Kansas City.

Q: You mentioned that on the Missouri itself the largest work was in the major urban areas. How about the balance of urban to rural flood protection?

A: Well, on the Missouri, we've got levees of some kind for the whole length of the river from Omaha on down. Some of the levees are federal levees, not federally-owned but federally-sponsored and constructed for the local sponsors. Some are what we called private levees which were built by the local people. Down in Kansas City, particularly below Kansas City, the whole river is leveed, with levees near the river, but most of those are private levees built by the farmers.

They may be 20-25 year levees or levees that might protect against floods that might be exceeded four or five years in a 100-year period. The private levees tend to be lower than the levees that we built around the major cities, which we designed for our standard project flood, a very large flood that would have much less than a one percent chance of being exceeded in any one year.

Q: On those that you allow the local people to build, they. . .

A: We don't allow them to build them at all. We don't have any jurisdiction. They can build them.

Q: So you have no control over what they put up?

A: No, we do not, unless they get them so close that they interfere with our bank protection and navigation works. Then we can control that because they're interfering with the structural integrity of the federal navigation project. Because if one of those levees gets overtopped and it flows out, a big "blue hole" is created. If the levee is too close to a bank revetment, the levee blow-out will take out a segment of revetment as well. As far as I know, there are no federally-owned levees on the Missouri River. They're all federally-constructed and then turned over to the levee districts or to the city. The city owns them and operates them, and we inspect them once in a while.

Q: The local cooperation agreements are the key, then?

A: Correct.

Q: What about the flood protection in the major urban areas with which you dealt?

A: Omaha, Kansas City, Sioux City, Denver, Topeka, Sioux Falls, Rapid City, Lincoln. But all of these places I mentioned have had major urban floods where we have gone in and usually have built projects, urban projects.

Q: Do you want to take each of the urban areas and highlight what you did there or what your experience was in them with flood control?

Omaha and Lincoln, Nebraska

A: Let's start with Omaha. For years since about 1960, we've been building portions of the Papillion Creek project, which includes some channel protection works, which involved some channel enlargement to carry floods, some levees, and then these dams that we already talked about on both the Big and Little Papillion Creeks, including the levee that you might remember on Papillion Creek where it goes by Offutt Air Force Base. We were involved with that design.

Now, over in Lincoln, we built, I think, seven reservoirs. Maybe you've seen those.

Q: I've seen some of them.

A: Wagon Train, Branch Grove and so forth, Holmes Lake, all around the periphery of Lincoln in the Salt Creek watershed. We were involved with those dams and with channel work through Lincoln, itself.

Sioux City, Iowa

In Sioux City, I was involved in one way or another with three different projects. There are three streams there. Floyd River and Perry Creek flow through the town, and the Big Sioux River flows along the north side. We had projects on all three of those streams.

The Floyd River was very important. There was a big flood in 1953 that just about wiped out the stockyards area in Sioux City and flooded much of the downtown area and drowned about 27 people. It just washed down through town and flushed the packing houses into a big pile of debris right down on the Missouri River bank.

Anyway, we went in there and built a new channel for the Floyd River. It started upstream several miles and was protected by rock on the side slopes. The study to find out what size rock to put on there was a major involvement, aside from the layout and the hydraulic design.

Then the project that we've been studying ever since I came to work for the Corps was on Perry Creek in Sioux City. It was one of the first water surface profile studies I made when I worked for Nick Barbarossa after I arrived in Omaha. Finally, this year, 47 years later, the Perry Creek is under contract for construction. It might be one of the last local protection projects that Omaha District has. They're building a new channel and concrete channel for Perry Creek. So off and on for over the 45 years, I was involved with Perry Creek. These projects sometimes stay on the books as inactive studies for an awfully long time, until a big flood comes along and activates enough interest to get authorization for construction.

The third stream at Sioux City is the Big Sioux River which goes along the north side of town. There we built some bank protection and levees on the Sioux City side.

Denver, Colorado

Now, let's see. Out in Denver, we've had all kinds of studies and projects. Of course, we've got some major dams such as Chatfield, Cherry Creek, and Bear Creek.

Then we studied channel improvements down through Denver. Except for one segment of channel improvements on the South Platte just below Chatfield, we didn't end up building anything because we never could get the local cooperation lined up. Probably was our own inaction. We couldn't get in there and move fast enough, but we did a lot of studying out there.

Kansas City Area

Q: What about Kansas City? Kansas City, I know, is certainly a pivotal place for flood control after the floods of the early '50's.

A: We've had several projects in Kansas City and fairly good political support, I guess, because we've had quite a few projects there, aside from the levees on the Kansas River and the Missouri River. Of course, the Kansas, you know, comes into the Missouri there at Kansas City. There are major flood walls along there. We've had major projects on the Little Blue River that flows through Kansas City and the Big Blue River, which goes just south of Kansas City, and Brush Creek. Are you familiar with Kansas City at all?

Q: Yes, I spent some time there.

A: Okay. You know where the plaza is. Country Club Plaza?

Q: Yes.

A: Well, Brush Creek is the stream that goes by the plaza. Several years ago, they had a big flood on Brush Creek that put water up into the basements of some of the stores in the plaza and into some of the parking garages. There was a project on Brush Creek. We enlarged that channel, did some major extensive model studies, and the Corps has just finished that Brush Creek project.

Then there are long levee projects on the Little Blue and the Big Blue River. The Big Blue River goes through the industrial area, through the old steel plants down there on the east side of Kansas City. We completed a concrete and rock-lined channel project up through what used to be the ARMCO Steel Plant. An earth channel extends to Swope Park. There were several projects in the Kansas City area, channel improvement projects, one of which is still under construction and that's the Blue River.

Other Urban Projects

Now, there was a project I recall on Weirs Creek which goes through Jeff City [Jefferson City, Missouri]. There was a big concrete channel with a lid on the top, that goes past the state capital there. There were all sorts of projects at small towns throughout our area in Kansas, and in Nebraska, and South Dakota, little levee projects to protect the towns from flooding. There were dozens of them. Channel and levee improvements we call them. Not very many concrete structures, but channel and levee improvements. Topeka, another town where there's a Corps project. As they occur to me, I could make you quite a list.

Problems with Project Approvals at OCE

Q: You mentioned that you studied the problems in the Denver area very intensely but didn't do much there. Was that a matter of opposition?

A: Partly, yes. There were several things going on. The cities did a lot of the work themselves because the Corps began moving slower and slower. You'd send a project to be reviewed through the division office and to OCE, and it might take years to get an answer back. In other words, the higher echelons had no respect for the time schedule of the people at the lower end who were trying to get the projects going. They were ruthless when it came to holding up the project.

Q: I'm sure you questioned them many times as to why they were so slow. Was it just the procedures?

A: I don't know. Of course, when I got to division, I probably contributed some to the inertia myself. I may have asked questions and so forth. It's just a big bureaucracy and several echelons of review and approval. Then, when all of the environmental issues surfaced and we got all of these rules, all of the special rules for planning and economic justification, it just took forever. It took years to get these projects going. So I think, probably, we lost a lot of work out in Denver because we didn't move fast enough. Take Section 14 projects, for example. Do you know what Section 14 is?

Q: No.

A: That's an emergency authority for protecting transportation facilities, bridges. Basically, if the bridge gets endangered by a flood, the Corps can come in under Section 14 and drop some rock around the bridge or do other things, firemen work. Well, there was one era there when the Assistant Secretary of the Army for Civil Works had to approve the funds for dumping of several tons of rock under a bridge out in the middle of Nebraska some place. It had to go up there for approval. Of course, the inertia was such that we never got approval for these things. We invoke a so-called emergency authority, and maybe two years later we get authority to put the rock in. I hope they've streamlined the process by now.

The higher-up people did not trust the lower-down people, did not trust them to make sound decisions. Lack of trust was basically the problem. Therefore, these emergency authorities we had--the Corps got its reputation for moving quickly, getting in there and getting things under contract--we lost all of that advantage when we got embroiled in the review chain, this is my view anyway. When we allowed ourselves to get embroiled in this review chain, timely emergency action suffered.

Also, we got into some of the later administrations where they wanted to hold up action on projects. They wanted to get the Feds out of constructing these projects.

Q: Was that Mr. Gianelli in the Reagan Administration more than anyone else?

A: He was one of them.

Q: And Bob Dawson?

A: Yes, that's right, these people. Basically, this is my view, instead of coming right out and abolishing the Corps' authority to do these things, they just permitted a slow, agonizing, and frustrating death for the program with all of the inertia, nitty questions, lack of trust in both directions, and so forth. In other words, instead of maybe letting the patient die quickly they created a slow cancer. So that's really what happened to the Corps' ability to move quickly in some of these areas, in my opinion.

Authorizing and Funding Local Protection Projects

Q: On these local protection projects, did you find that most of them were requested by local authorities?

A: That's how they handled these. The local authorities go to their Congressmen, and they request that the Corps make a reconnaissance report. This is how it works, theoretically, anyway. The Corps goes out and makes a reconnaissance report and sees if there's any economic justification for working on a project in that area, but the locals have to request it.

If the Corps makes a reconnaissance and decides there's a possible project there, they apply to OCE for funds to make what was called a survey report. Congress appropriates money every year for the Corps to make what they used to be called survey reports. The survey reports present a preliminary layout and design, demonstrate whether they would be economic justification, lays out the requirements for local cooperation, etc.

Then, if the survey report demonstrates a feasible project, the locals support it. They seek authorization from Congress. Then, when it's authorized, Congress then appropriates construction money. That is the money with which you make the final design and build the project. That's all done in connection with the local sponsor. Without the local sponsor on board every step of the way, that project will not go. The sponsor has to be willing to take over the project when the Corps gets through building it, so he has an interest in this thing being designed right, designed to work right, with reasonable maintenance.

Q: Aren't they also now forced to pay a larger percentage of the costs?

A: Yes, at one time they used to provide the land. The new rule is where the locals would provide the lands, the easements, and the rights of way, and all bridges and relocations except for railroad bridges. Now it's also a percentage of the cost. I don't know what it is now. For a while, it was over 50 percent. Now, for these urban projects this does not usually present a problem. For example, on the Floyd River in Sioux City, the city had to provide the new street bridges. This is an idiosyncracy of the law. The locals pay for road bridges, but the U. S. Government will pay for railroad bridges.

In urban projects, by the time the locals get through meeting those local cooperation requirements, they've automatically contributed a big chunk of money, maybe 50 percent of the project cost.

But in the more rural projects, that's another story. The locals don't have as much invested, so they've got to maybe come up with some money in addition to the land, easements, and rights of way. I don't know, maybe you know what the requirements are now, but it's at least 50 percent.

Q: Well, it was 50 percent, I remember, from the middle '80's.

A: In allocating limited construction funds among authorized projects we would first go to the sponsor that's willing to contribute the most. In other words, the projects that have the most local contributions are the ones that are going to get built first. That was the policy at one time by the time I was leaving the Corps.

Effect of the Water Resources Development Act of 1986

Q: Well, the Water Resources Development Act of 1986 changed a lot of those proportions of cost-sharing. I've got an account of that here, but I was just trying to take a quick look at it to see if it says anything about the proportion.

A: I don't know. Of course, if you want to talk about that, you need to talk to somebody else because that was near the end of my career, and I was not really in that project formulation area in 1986. I was on the periphery. I knew what was going on, but the planning people became more and more exclusively involved in that sort of thing. The planning became an entity in itself within the Corps, aside from engineering.

Q: There's a whole series of different percentages in this Water Resource Development Act.

A: It depends on the project purpose, doesn't it?

Q: Yes.

A: Water supply is one thing. Flood control is one thing.

Q: Harbors to a certain depth.

A: Yes.

Q: And increasing beyond that depth. Let's see. Construction costs: Federal 70 percent; Non-federal, 30 percent. 100 percent of incremental costs for increasing harbor depths beyond 45 feet. That's an example. Let's see here. Non-federal interests pay 100 percent of Operations and Maintenance (O&M) costs for other water resource projects and a percentage of the new construction costs according to the following formula.

A: Okay.

Q: And hydroelectric power, 100 percent.

A: That's always been the case.

Q: Recreation, 50 [percent].

A: I think it used to be 100 percent of everything above basic facilities.

Q: Flood damage reduction, 35 [percent].

A: Yes, that's pretty close to what it was.

Q: Hurricane storm, 35 [percent].

A: Water supply was always 100 percent.

Q: Agricultural water supply is 35 percent.

A: Oh, really?

Q: Fish and wildlife enhancement, 100 percent.

A: Yes.

Q: I'm sure there are more here.

A: You've got a big, long shopping list.

Q: Yes, I guess it's all tailored to who had the most influence.

A: Anyway, fewer and fewer sponsors were interested in coming up with this kind of money, unless they were maybe in an urban setting with a terrible flood problem. Then they usually had a big flood. Then they got interested in the project.

Q: They were more than willing to pay?

A: When they have a huge flood, then all of a sudden they're willing to pay. Then, if the Corps didn't drag its feet too long in putting the project together, the project might proceed. But, if the Corps fooled around for several years, then the locals lose interest in it and they have other reasons for their money. Then you have to wait for the next big flood.

Q: There are a lot of different formulas there.

A: You may have heard some of this from Vern Hagen.

Q: Well, yes, Vern talked a little bit about it. Let me go back to something that you mentioned that certainly impinges on this whole question and that is the change in the economic justification policies for projects that changed very markedly over the time you were there at Omaha and MRD.

A: I don't know. In the Flood Control Act of 1936, you figured the benefits based on to whomever they may accrue, and I think this pretty much described what we always did.

Recreation Benefits

Q: Yes, but we were talking last night about recreation. Recreation was nothing, and then it become very important.

A: I forget who the senator was or Congressman, but he put a rider on one of the bills that said that recreation can't justify more than 50 percent of a project. That was a Congressional requirement. So in other words, you come up with a project that has a lot of flood control benefits and, then, if you're unrestrained in putting in the recreation facilities that generate lots of recreation benefits, you may be in trouble.

If you put in too many of these recreation facilities, like camping pads and what have you, then according to the criteria they had, each one of these facilities creates additional benefits and so pretty soon, if you're not careful, you're going to get the benefits up to more than 50 percent of the project and you can't build it. One of the jokes at that time, was, "Well, we've got these reservoir lands, and we're going to put a fence around half of them so we can meet this Congressional requirement."

Q: So half of them couldn't be used?

A: Yes. Of course, that was partly facetious, but it was the unintended consequence of this rule where you're restricted to 50 percent of the benefits being recreation benefits.

Q: Well, I know that in the '30's and into the '40's, there was very little leeway for recreation benefits to be counted at all.

A: When I first came around in the '50's, recreation benefits didn't even exist.

Q: Right. Was that Kerr or McGee who originally put the benefits in because they were using it to justify some of the Arkansas River projects?

A: No. It might have been Kerr. If it was the Arkansas River, then, undoubtedly, it was Kerr.

Q: I think he did it. I think a lot of that was in the late '50's and early '60's where they started adding recreation and then somebody must have said, "Hold on."

A: I don't know the history of that, but somewhere along the line these recreation benefits came in and it became easier to justify some of these projects once that happened, because they weren't just incidental benefits. You can enjoy incidental benefits that really didn't justify the project, I don't believe. Then the policies changed, and we could then include recreation benefits for economic justification.

Estimating Project Benefits and Costs

Q: How do you go about estimating the benefits on a project? I can understand how you estimate the cost, but a lot of the benefits are sort of difficult to estimate. Aren't they just guesstimates?

A: Well, it's a little bit of crystal ball. The flood control benefits are pretty straight forward. You have a flood series, this is an example. You take a flood frequency curve which gives the probability each size flood would be exceeded in any one year. You figure out downstream what the damages would be for each flood. With this information you can get an average annual flood damage without the project with this flood series that you put down through there.

Then you put the flood series in with your project in, which might include a dam which stores some of the water. It might include a channel and levees to confine the water and keep it from going on and flooding the valley to the sides. You figure out what the average annual damages are with the project in place. Then the difference in damages between the two, with and without completion, is the flood control benefits. That's pretty straight forward, I think.

Figuring agricultural damages along the Missouri River sometimes is very complicated. Al Cochran was into that quite heavily down on the Mississippi. Then I got into it on the Missouri River where you actually model a series of floods in any one year. The first flood in early May might wipe out the new corn that was just planted. Then you replant in May, but might get a late May flood that wipes it out again. Then, if it's too late to replant corn, you may replant with soy beans. Then, if don't get any more floods, you harvest the soy beans, but you still have to include in your production costs the costs of the earlier plantings. In other words, you just model the whole sequence of planting, flooding, replanting, and harvesting on the flood plain for an entire season.

Anyway, I wrote a model that simulated the agricultural production and flooding sequences on the Missouri River flood plain. You've got to use criteria that the Department of Agriculture comes up with. Replanting procedures, crop yields, the harvesting, what damage you get when the corn has various depths of water on it, and so forth. That was all taken into account.

Now, the recreation benefits. They've come up with some graphs that estimate the annual benefits of various types of recreational activity. You make a study to see what urban areas are nearby and who's going to come to your project. If you've got so many acres of one kind of activity, the annual benefits are so much. They have criteria where they assign the recreation benefits for each of many activities, soccer fields, tennis courts, camping pads, you name it. They come up with a carrying capacity for certain types of campgrounds, and you postulate how many people are going to come up there from how many miles away.

Then there is fishing. A lake in a certain geographic location, acreage, has a certain carrying capacity for fish. This has a certain fishery benefit per day of fishing effort.

Q: This all sounds like a big game, doesn't it?

A: Yes. It's all a crystal ball game. If you tell the planners what you want to justify, they can usually justify almost anything. That was my experience. That's what I thought I was seeing.

Q: I guess you hire the most creative imaginations who can come up with these things.

A: Now, hydropower benefits were often based on the cost of the fossil fuel plant you would have to build in the absence of the hydro plant. If you're providing a certain peaking capacity, then the benefits from peaking the hydro plant would be the cost of the gas turbines they would have to add to the power system if they didn't have peaking capacity of the hydro plant. Again, that's an alternate fossil fuel alternative.

Q: Are these the kinds of things that when they go up to division and then up to OCE would be the ones that were questioned and worked over?

A: Well, there were definite criteria that were applied when coming up with these benefits. In other words, criteria were supplied downward from OCE or from the Federal Power Commission, regarding power benefits. Yes, these things might be discussed or argued about, but the criteria were clear cut. There were all kinds of regulations, and technical letters, and this sort of thing which described how you were supposed to do these things. You applied the cookbook, you applied the rules, and then the reviewers just look at it to see if you followed the rules.

Q: How much were you involved in helping to make those rules?

A: None. I wasn't involved in the economic criteria at all. Those come from on high from the Chief's office, from Washington.

Q: So you were just providing information?

A: I was involved in providing the cost of the project, from the engineering standpoint. I was never involved in making the rules for economic justification of projects.

Q: The costs are a lot easier to predict, aren't they?

A: Yes.

Q: But over a long period of time that some of these projects took, the costs had to be difficult to project, where you have periods of high inflation, low inflation.

A: Oh, yes. Well, there were rules about that, too. The interest rate that could be used for justification was specified by the OMB, the Office of Management and Budget, I believe.

Q: I think that's right. First the Bureau of the Budget and then OMB.

A: OMB. Eventually, the interest rate was tied to the rate the Government paid for money. When I first came to the Corps the interest rate that we used was 2 5/8 percent. The amortization factor of that was 28:1. In other words, you can spend 28 times the annual benefit. That's the limit you could spend and still get a 1:1 benefit to cost ratio. Since then the interest rates have risen and as the interest rates rise above six percent, this ratio goes from 28 down to some lower number, like 18, which means the project must cost less than 18 times the annual benefits if you are to have a B/C ratio above unity.

Q: How often did you come up with projects that could not pass the 1:1 cost-benefit ratio?

A: I think we had quite a few that were marginal, where the planners really had to stretch. Many projects had clear-cut justification. But some were what we called "dogs". You really had to stretch to justify them. In the early days, you might fall back on words like "this project is unquestionably justified," this sort of thing.

You're allowed to put in intangible benefits and this sort of thing, provided that the people up above you will buy it. If there would be a tremendous loss of life if you don't do the project, we avoided attaching a dollar value to the human lives we might save, although we might highlight this as a substantial intangible benefit. I've always had a problem with the morality of that, putting a number on somebody's life and then saying, "Well, if this dam fails, you're only going to kill 200 people. That's far less than what it would cost to fix the dam," this sort of thing. Some economists go for that.

Q: Yes, they want to quantify everything.

A: But I want to ask that economist to build a house right below the dam and live there if he wants to take that view.

Q: Yes, they probably won't do that.

A: After all, chances are he wouldn't be hurt. Chances are.

Computer Model for Calculating Flood Damages

Q: Chances are, right. I think we've covered a lot of that. Is there anything else in that area? You said you developed a model for calculating these flood damages. That's like what you did for the diversions. When was that? Was that after you had better computers or you had more familiarity with them or was that early on?

A: That was when we had better computers.

Q: When?

A: I can't tell you when it was. It was probably around 1970 or so.

Q: But, again, there was no commercial software program on the market that you could use.

A: That's right. These agricultural damages on the Missouri River were a result of more than one flood a year. I described it to you. The flood comes and keeps them from getting into the field and planting, or destroys what you just planted. Then you replant and might get another flood. We broke our analyses into 15-day periods. We studied the history on the flows on the river for the period of record that you've got. Each 15-day period has a certain probability of having a certain size flood.

As you get later in the year, the probability is, of course, very low, so chances are the crop will mature and be harvested, and so forth. But there's a certain probability that the flood will come along and either damage or destroy your crop. If it's early enough, you have time to replant. If it is later, you lose everything. All of that can be modeled in a simulation of the growing by 15-day periods. I put together a model that was used by the planners in our districts.

Q: Now, that has to put a bigger burden on you because you have a lot of other things to do, too.

A: Well, these things were interesting. I feel as though I really enjoyed my career. I did some interesting things.

Navigation Improvements on the Missouri River

Q: Well, let's go on to the question about navigation improvements. I imagine that most of the navigation improvements were on the Missouri because there's very little else that's navigable there?

A: You mean those that I was involved with?

Q: Yes.

A: Well, there's about 700 miles from Sioux City down to St. Louis that's an authorized navigation project with a 9-foot channel. While in MRD, I spent quite a bit of time overseeing the design and the criteria for maintaining the navigation structures, the dikes, and revetments that control this channel.

Q: When you were in the division?

A: Yes.

Q: When you had both Kansas City and. . .?

A: In the district, that was not in my bailiwick, but in the division, it became my bailiwick.

Q: So when you went to the division, you had all of that mileage?

A: Eventually. When I first went to the division in 1964, for example, I just had hydraulics. But soon I had both hydraulics and hydrology. Then, after a few years, a couple of years, Don Bondurant, who had still been there in the division, retired. I inherited the sedimentation responsibility. About that time, they moved the river work from operations to engineering, and I took over the river work as one of my responsibilities. I gradually accumulated these various responsibilities.

Q: Do you want to talk about the challenge of the navigation channel?

A: The challenge?

Q: The challenge to keep it open?

A: Well, I guess we met the challenge by brute force. First of all, one of the functions of the reservoir system, these huge dams with lots of carryover storage, was to maintain navigation flows of around 30,000 cfs at Sioux City during the navigation season, that was roughly 15 March to 15 November.

As you go downstream on the river, you pick up flow from the tributaries, the Platte, the Kansas, the Gasconade, the Osage, and some others. By the time you get down to St. Louis, the navigation flow is about 50,000 cfs. In order to get a 9-foot depth and make sure there is a regular sinuous trace that the towboats can follow even at night, we contracted the channel within a system of dikes and revetments.

The narrower width caused the river to scour out its bed and maintain this 9-foot depth. Of course, in bends, you've naturally got a deep channel on the outside of the bend, obtaining navigation depth is easy. But in the crossings between bends, you tend to have a crossing bar, a shallow sandy area, so in the crossings we had to put in special contraction works in order to maintain navigation depths.

Of course, as you go downstream from Gavins Point Dam, you pick up more and more unregulated tributary flow. Consequently, the navigation channel is subject to occasional flood rises. It is natural in rivers that the high floods deposit sands in the crossings. When the floods are gone, these deposits remain in the crossings forming shoals which have to be cleaned out of the navigation channels. Now, if we have contracted the river properly, the river washes out its own channel through the crossings. If the river does not do this, the crossing must be opened by dredging.

In the early days of navigation on the Missouri, we had the dredges operating in some of these crossings where there were trouble spots. But the dredges were very expensive and they moved so slowly up and down the river we couldn't respond quickly to all the trouble areas when we only had two dredges and we had 700 miles of river. Fortunately, our navigation structures were very successful. In the early years of the project, only limited dredging was required. In the latter years, the dredges were all retired, and the contraction works were able to maintain the navigation channel without the need for dredging.

Q: What did you mainly use for this? Was that wooden or sheet steel piles or rock?

A: Well, up until 1950, we had wooden piling with quarried rock dumped in among the piling. But, about 1950, they found out that really the piling was not really necessary, so almost 100 percent of the structures after that time were dumped rock. The rock quarries we located at various points along the river.

Q: So it was just a matter of filling up certain sections of the river to push the water into the channel where you wanted it?

A: Of course, when the river is 30-feet deep, you've got to really fill quite a section, you know.

Q: That's a lot of rock.

A: An awful lot of rock involved, yes. By the 1980's, however, the maintenance costs in terms of rock dumped into the river were very low. We came through several major floods with some damage to the navigation structure, but not catastrophic.

Q: Did you use anything other than the quarried rock or was that pretty much the main material?

A: That is pretty much it. Now, we did experiment with other materials upstream from the navigation project, in the open river stretches below Garrison and Gavins Point, We constructed several so-called Section 32 projects. Section 32 of one of the flood control acts authorized demonstration projects to try various kinds of bank protection. For the navigation structures, we used mainly limestone with 2.5-2.4 specific gravity or even Quartzite with about 2.65 specific gravity.

But up in these areas where we were doing these demonstration projects, we actually used quarried chalk and shale with only 2.0 specific gravity. It's a soft rock, and if it's exposed to alternate wetting and drying, it becomes mud after a season or so. But as long as the chalk or the shale are submerged in water and stay under water continuously, then they're really a very tough construction material. We constructed the lower parts of a lot of dikes with the chalk or shale quarried from the bluffs along the river.

Then we also tried what we called windrow revetments. We'd go behind an eroding river bank and lay out an alignment where we wanted the bank to be maintained. Along this alignment we'd dig a trench which was basically above the water level and we'd fill it full of rock to the ground surface. Then, when the river bank eroded over to that trench, the rock rolled on down and created a nice revetment. We tried many other things, including short spur dikes or hard points which were not successful.

We tried to manage the river which, I think, had great promise. I think I mentioned sometime before that the natural river has multiple channels. We constructed some channel blocks that blocked some of these channels that were adjacent to the high banks so the river couldn't flow along there and erode the high banks. Other channels took up any flow from the blocked channels. Under Section 32, we tried quite a few different things, and I think they're still observing the demonstration sites and writing a report.

Q: That's the streambank erosion program?

A: Yes, that was Section 32. The Streambank Erosion Demonstration Project. Various offices throughout the Corps had some of this money. Omaha District had a pretty good chunk.

The Channel Stabilization Committee

Q: How much did you get involved in Channel Stabilization Committee?

A: There is a Channel Stabilization Committee of the Corps that Douma ran. Don Bondurant was on that committee. After he retired, I became a member of the committee. I was on that committee for 10-15 years. They met a couple of times a year in various locations throughout the country where a Corps office had a particular stream control problem. We would meet as sort of an advisory board and take a look at the area and then make our recommendations as to what might be done.

The Corps of Engineers Channel Stabilization Committee, an official committee of the Corps, was chaired by Jake and then by Sam Powell, who took over when Jake retired.

Q: Yes, that's what it is.

A: Bank protection was part of the deal. The committee originally was involved only with the big rivers like the Mississippi and the Missouri. Then gradually over the years, it transitioned to problems on the smaller streams throughout the country.

Q: But it was mainly an advisory board?

A: Well, it was sort of a. . .

Q: Consultancy?

A: I wouldn't call it consultant. I'd say advisory board. We just visited and pontificated and gave the local district probably 150 percent of the advice they really wanted. There was nothing binding in what we did. We didn't approve anything. We approved it in the sense we said that so and so was a good idea, so and so was a bad idea, but we didn't have any reviewing authority. We gave them the benefit of our advice. Among us, we had quite a few years of experience.

Q: So you had a lot of good advice to give?

A: Well, I think so. That view might not be generally shared. It was a very satisfying thing. Even after I became chief of technical engineering, I still held on to my membership on that committee because it was really enjoyable and professionally satisfying.

Q: Kept your finger in the engineering side?

A: I kept my finger in that.

Q: Basically what that committee was doing was just trying to keep the channels clear and provide solutions for keeping the navigation channels clear for these districts?

A: Well, it basically had to do with the stability of channels that are in alluvial erodible material. Basically, most of the problems involved stabilizing the location from the bank cutting, degradation, the aggradation, and that sort of thing.

Then there were other problems, too. One time we got into a big discussion and study on what's really the roughness of a concrete channel. That was at Phoenix, Arizona. We had to go back into the fluid mechanics literature on granular roughness and this sort of thing. So the committee got into all kinds of things. Basically, it was on the stability of channels, eroding, head cutting, bank caving, and what to do with the stream that is really misbehaving and making a big mess of itself. We were involved in the Snake River going through Jackson Hole. The Tanana River up in Alaska. The Los Angeles River.

Q: What river was that in Alaska?

A: The Tanana?

Q: Okay.

A: Over the years, we went to quite a few places throughout the country.

Q: That work was very closely aligned, I imagine, with the work that was being done on the streambank erosion situation.

A: Well, the streambank, you're talking about Section 32?

Q: Right.

A: Well, that was only about a 5-year project.

Q: This was continuous?

A: Right. Section 32 was just one segment of time within the life of this Channel Stabilization Committee. The Channel Stabilization Committee was not directly responsible for that either, although they observed the results of the streambank erosion studies.

Q: Well, Jake made it clear that the Section 32 streambank erosion business was definitely separate from the channel stabilization committee.

A: Furthermore, they formed it without coming to an agreement with Jake, as far as I know. He wasn't very happy with it.

Q: No, he wasn't. He didn't say he was, but he was involved with it, apparently. That makes you wonder how influential you are, doesn't it?

A: Yes, that's right.

Environmental and Water Quality Operations Studies

Q: What other Corps-wide or division-wide committees were you on?

A: For several years, I was on the review group for the Environmental and Water Quality Operations Studies (EWQOS). This was a $25 million authorization for research into the hydrodynamics and the environment of lakes and streams and their fisheries. The research aimed at providing the understanding and the analytical methods that would help address these types of problems at Corps projects. There was another committee, I forget the name, but it was the committee that met Corps-wide to talk about the development of computers within the Corps.

Computers in the Missouri River Division

Q: That was in the '60's, early '60's?

A: This was in the '60's and '70's. Barbarossa was the computer activities coordinator in the division office because they had the Raytheon contract and Nick was involved with MIT in writing a computer simulation for hydropower transients. Then he left, so I became the computer coordinator for the Missouri River Division. Meanwhile, both districts had acquired computers of their own.

I visited the both districts and was in on their acquisition of their new equipment and this sort of thing for several years there before I realized it was getting to be a day-to-day activity which was more than I could handle, adequately, as a colateral duty. So we got a very good man, Bob Hunt, from the Omaha District, who was in charge of computers in the Omaha District. He came up to the division office and took over that computer coordinator job, and it became a fulltime job for him. He built a successful career out of that.

But anyway, in the early days, I was the computer coordinator for the division and was in on the acquisition of new computers with Omaha and Kansas City and so forth. As I mentioned, I was quite active in using the computer myself, although I got rid of the coordinator's job.

Q: Right, you did.

A: My use of computers was in writing programs for models in FORTRAN, or in Bell-1 or Bell-2 for my earlier efforts. I never knew how to push button number one on those big computers. I never actually operated a computer. I flow-charted and wrote the program, but I turned it over to someone else to run. When our own computers had too small a capacity for our programs, we would go to big computers at a university or the Bureau of Standards in Denver.

Q: What was your impression of how quickly the Corps in general took to computers? I know it was slow at OCE, apparently.

A: Yes, they were. Yet they were pretty fast to turn out regulations that made it very difficult to acquire equipment in the field. That was one of the things we fought all of the time. I was on this coordinating committee I was telling you about.

Q: Bureaucracy is bureaucracy, isn't it?

A: That's right.

Q: I guess what they saw in computers was that it cost money and it wasn't going to be easy to control once they got going out in the field. It reminds me of the whole process of getting desktop computers in the early '80's, and I'm sure you went through this like I did when I was in OCE. The obstacles almost made you want to say, "I don't want to do it because it's such a waste of time." Now, you walk in and say, "I want a computer," and they get it for you.

A: Well, that happened about 1980 in our office. Bob Hunt, who was a close colleague of mine, and whom I mentioned before, was the EDP [Electronic Data Processing] chief. It suddenly happened that you could get anything you wanted without any argument. By the time I left the division, there was a computer on everybody's desk, and a lot of computers were hooked up to a central file server for distributive processing.

There was a big mainframe computer down in the Omaha District that did the payroll for the entire Corps. This began early in my involvement as MRD computer coordinator. In the late 1960's, each Corps office was still doing its own payroll by hand. Then Omaha District decided to try and automate their payroll. So Bob Hunt, who headed the district's computer center, assigned a civil engineer named Dick Malm to write the program. The program was successful and soon Omaha District was processing the payroll with its computer system. This evolved to the point where finally the Omaha District ended up doing the payroll for the entire Corps of Engineers up until very recently. I don't know what's happened to that.

Q: I always appreciated getting those checks from Omaha District. I always did.

A: Well, Omaha was the one. This was Bob Hunt, a good structural engineer, and Dick Malm, another good structural engineer. From my position as computer coordinator in MRD, I supported them. We had to fight the battle to get Kansas City District to acquire the same system so that both districts could exchange programs and reap the benefits of developments in either office.

Q: Compatibility problems, you mean?

A: Well, Kansas City District wanted to acquire different equipment. I guess I forced them to get the same computer equipment, the RCA 301, the same computer equipment that Omaha was getting. They weren't very happy about that, but I could see the benefit in both districts having the same computer equipment.

Q: Was there ever any effort on OCE's part to have standardized computer selection?

A: Computer selection was standardized.

Q: I mean as far as type, a brand or. . .

A: Not that I know about. If you're really curious about that, you could talk to Bob Hunt. He's retired now. He has a handle on the development of computers in the Corps better than anybody else that I know.

Q: It appears from what we know from our level that the field was far ahead of the headquarters in computerization.

A: Well, of course, headquarters is really not an operating organization. They really didn't have immediate use for computers, although they ended up with desktop computers and this sort of thing.

Q: Right. But, apparently, Bill Whipple, Colonel Whipple, was the one who pushed them into computers in the later '50's, and they were sort of dragging and screaming to go to it. They didn't want to do it. But that's one of the things that we had noticed.

A: Well, they didn't have a lot of tasks that lent themselves to using the computers effectively.

Q: Yes, the big mainframes and things like that, yes.

A: Oh, yes.

Q: But even in the early '80's, was there still a lot of dragging your feet as far as automation was concerned?

A: Yes.

Q: It's always interesting to find out how far the field was ahead of the headquarters in some of these things.

A: We were ahead in the field. Until the 1980's, the rules that the headquarters put out actually inhibited our ability to get new equipment.

Q: I know it inhibited my ability to get it.

A: Where were you then?

Q: I was at the headquarters from 1978 to 1988.

A: Of course, up there Sam Powell or somebody had a Wang system, a little desktop system.

Q: They had the desktops. Right.

A: Desktop type things that they were playing with.

Relocations of Towns, Roads, Railroads, and Utilities

Q: Well, we've covered an awful lot. I was looking back over your vita and my questions. It looks to me like we covered most of your career, not dividing it up into your time at Omaha District and time in MRD.

One thing I didn't ask you, although we touched on it both in flood control and a little bit when we talked about Niobrara, was the whole problem of relocations when you're doing a large civil works project like the mainstem dams. They can get to be very difficult and very costly. Can we talk about your experience in dealing with relocations?

A: Of course. Niobrara was relocated after the project had been in operation for awhile, and it was apparent that there was going to be a problem.

Q: Right.

A: But we didn't relocate too many towns. There was one, it's on the Garrison Reservoir. I forget the original name of the town, but it's now called New Town. It was relocated up on the edge of Garrison Reservoir as part of the construction project because it would have been down in the reservoir.

But outside of that one, we didn't relocate any complete towns. Now, we protected a lot of towns. I mentioned levees around Williston at the headwaters of Garrison to protect against the backwater of the Garrison Reservoir. Tuttle Creek had the town of Frankfort [Kansas] in its headwaters. There were levees and so forth around Frankfort to protect against Tuttle Creek.

Then, of course, you've already brought up the subject of Niobrara, but there weren't too many towns relocated. I think I've named the two that I can think of right now. I may think of another one.

Q: How about the problem with relocation of roads and utilities?

A: There were millions and millions of dollars worth of that kind of relocation. Railroads, roads, utilities and so forth. Lots of those relocations. New bridges, railroad track relocations, and highway relocations. There were many miles of those on a lot of our projects.

Q: On the big mainstem dams, you must have had particular problems with the railroads.

A: Yes, there were some major railroad crossings that we had to provide. At that time no one was more hard-headed and hard to get along with than a railroad chief engineer. So we had a lot of negotiations, a lot of meetings and so forth. We hashed out relocations for all of the major tributaries, the railroads across the major tributaries that go into Oahe, for example, and across Oahe Reservoir itself. We went up to the railroad headquarters and the various railroads and spent lots of time, lots of money, building these things. Then, ironically, about the time we got through filling the reservoirs and constructing the relocations, the railroads started abandoning many of these lines.

Q: Is that right?

A: Oh, yes. That was the era in the Dakotas when they began to consolidate and abandon railroads after they let us build all of these relocations.

Q: Which they probably knew they were going to do.

A: Many of them were abandoned. Not all of them.

Q: Those kind of things didn't present any real significant problems, did they?

A: When you look at it as a taxpayer, you think "Well, this is too darn bad. The railroad took us for a ride."

Q: Well, you were saying the other day they had all kinds of desires, like in the flood control projects, because Federal money had to pay for the relocations.

A: The authorization for the Missouri River dams calls for the Government to pay for all relocations. For local protection projects, however, Federal money will pay for railroad relocations according to the law. But the Federal money will not pay for road relocations. That is a responsibility of the local entity, unless the law that authorized the project specifically authorized Federal payment for the highway relocations.

Q: I imagine there were a lot of local politicians who went to their congressmen and senators on those.

A: Yes.

Q: Especially in some of those rural counties in Montana, the Dakotas, and Nebraska where they don't have a lot of money.

A: Well, what I just said applies to all of our local protection projects. But for the dam projects along the Missouri River itself, even the highway relocations were Federal expense.

Q: I thought that was probably true because of the scale.

A: When you come to a town like Omaha, and you need to have a road raised or lengthened, or a new bridge, because of something you're building, it's up to the city or the county or the Natural Resource District to make that relocation at their expense. Strangely, I think we would pay for a bridge raise, but not a new bridge.

Career in the District and Division

Q: Now, as I say we've covered a lot of your time at both the district and division. Is there anything from your experience at the district specifically that you'd like to talk about anymore?

A: Well, I don't know. Much of my actual hands-on project formulation and design, that is performing the physical aspects of the project and design, were at the district level. At the division, I was more into reviewing and directing the overall oversight and technical guidance.

Q: More management?

A: But in the district, that's where we actually did a lot of this work. You actually did hands-on work. That's probably for me the most interesting part of my career.

Q: Down at the lower level where you're doing the actual engineering work?

A: Of course, we promoted a lot of interesting things at the division level, also. Got funding for certain kinds of tests, studies, and what have you, and oversaw those tests. We put our finger in the pie, you might say. All of my work with hydropower plant transients we talked about, I myself did that work while I was in the division office.

Q: So you didn't deal with that at the district level?

A: No, it was not until I went to the division that I got into this business of trying to model the hydropower plant transients. We had a contract with MIT to do this. I spent a lot of time going back and forth to Cambridge while they were developing this thing, to insure it would be an engineering tool when they got through and then applying it to certain projects when we got back to the office. We added some features to the MIT program to make it a more useful engineering tool.

Q: Trying to develop a practical application is an important thing though, isn't it?

A: Yes. At MIT, Professor Frank Perkins eventually became head of the Civil Engineering Department. I don't know if he's retired by now. Anyway, he was a very sharp and perceptive individual. He did an excellent job on that program. I learned a great deal from him.

Q: He's the one you said has the WHAMO shareware?

A: The name of the program is WHAMO-- Water Hammer and Mass Oscillation. Under a second contract with MRD, he took the original program that was tailor-made for the type of hydropower installations on the Missouri river and generalized it so it can be used for a wide variety of systems. A lot of people all over the world are using it.

Q: Well, that's got to make you feel good.

A: Oh, yes.

Organizational Structure

Q: If I get the organization right, you were then under the technical engineering branch?

A: No. At that time hydraulics and hydrology in MRD was in water utilization branch, which was something like the planning and reports branch in the Omaha District. Reservoir operation, hydrology and hydraulics, sediment, and reports were all sections in the water utilization branch. The technical engineering branch was another parallel organization.

The man who ran the branch was Bob Pafford, who was really one of the individuals most responsible for how these reservoirs are operated today, the formulation of the projects and how the reservoirs are run, and the local cooperation. His assistant was Tim Waara, Tarmo Waara. When Bob Pafford moved on to the Bureau of Reclamation in California to become district director, Tim Waara took over this water utilization branch.

Somewhere along the line, they broke out the reservoir operations section and created the Reservoir Operations Center (RCC) which became a separate branch. At the same time, they decided that hydraulics and hydrology would be moved over to the technical engineering branch. Asa Shannon, who was in charge of tech engineering, moved on to be the chief engineer in the Southwest Division. Then Ed Soucek came from Omaha District to be the chief of tech engineering. They moved me and Bondurant over to tech engineering. Whatever year that was, maybe 1970, so I ended up in tech engineering that way.

Q: So the whole section moved over, and they restructured everything?

A: Yes, my whole section moved over there. Then when Bondurant retired, I took over the sediment part of it. Pretty soon, the sediment, and hydraulics, and hydrology, engineering for the river work was all in my bailiwick.

Then, of course, when I first came up there, I inherited this computer coordinator job. So for several years, as I mentioned to you, I was the Missouri River Division computer coordinator.

Q: Right, you did.

A: The EDP coordinator. I was doing that job when I first went up there, and for the next three or four years.

Q: No, I didn't say they did have anything to do with it. They were going through the same kind of problems up there, and they finally put the structural, the hydraulics, and hydrology all together.

A: We did something that you'd probably get the OCE people to admit they could have done. I was lucky enough to have the hydraulics, the hydrology, the sedimentation, and the river all under one leadership, whereas in OCE and many of the offices these functions are dispersed, particularly hydrology and hydraulics. I think they looked sort of enviously upon this situation in MRD.

Q: Was there any one person that was involved in that?

A: This was, see, when Wendell Johnson moved up to the Chief's office, Jerry Ackermann moved up to Engineering Division chief in MRD.

Q: Engineering Division?

A: Yes. Ed Soucek moved from the design branch of the Omaha District. He became technical engineering branch chief in the division office. We had a good relationship. Frankly, Asa Shannon, who had been the chief of tech engineering for years, his relationships with a lot of these people wasn't so good. I had no problem with him at all. I was a younger generation and had no problem with Asa. But as Ed Soucek told me, he said, "We wouldn't force you to work for Asa. We wouldn't do that to you." This sort of thing, you know. It was just an aside. I didn't feel that way.

Anyhow, when Asa left for another job, they made the move and reorganized the way they wanted to reorganize. So, basically, it had to do with when the leadership changed. They had a different idea of how they wanted to organize the various engineering disciplines.

Bob Pafford

Q: I think it was Vern Hagen who talked about Pafford.

A: But I would say that if you're talking about Missouri River development, Bob Pafford would be as important for that as Gail Hathaway would have been for the whole Corps of Engineers. If he's still around, he'd really be someone to talk to.

Q: You say he went to BuRec?

A: He became a district director for BuRec out of Sacramento.

Q: I imagine somebody out there may know him.

A: Yes.

Q: But he spent most of his career with the Corps, didn't he?

A: Yes, that's right. He was an electrical engineer. He came to work with the Corps probably in the early '40's and then he left in the early '60's. I don't know exactly when he left. But a very capable, strong person followed him as chief of the Reservoir Control Center. This was Tim Waara. Tarmo Waara, a Finish name. Then Elmo McClendon followed Tarmo Waara, when Waara died.

So they had three really outstanding, strong people in charge of the operation of the reservoirs and at the Reservoir Control Center, which was established as soon as we started actually having dams in place. I worked with them regarding river engineering problems as they impinge on the questions having to do with operating the dams.

I'll mention again, Bob Pafford would be an interesting person to talk to, if he's still around. He's older than I am, of course, quite a bit.

Q: Well, I'll tell you one thing I found out. Before we talked about Slichter, we thought he was long gone. A lot of engineers live a long time, I'll tell you.

A: That's right.

Q: A lot of the folks I interviewed were way up in their '80's and still pretty active.

A: But if you're interested in all of the politics that had to do with putting together the Missouri River project, he'd be the person to talk to.

The Role of the Military Leadership

Q: How much of the change in the district and MRD was a civilian-directed change?

A: It was all civilian. At that time, the military did not, the general, the colonels, they didn't get into the act for things like that at all.

Q: They left that up to the civilian leadership?

A: It's only in this latter day that the district and division engineers have tried to be in charge and make those kinds of decisions.

Q: By historical precedents, that's a bad idea.

A: Yes, it's one of the things that's wrong with the Corps of Engineers now. Basically, the Corps of Engineers joined the Army and that's what happened.

Q: Yes, that was a big push. They were saying they were too much outside of the Army and they had to join it, but I'm not certain that that's been a positive thing for the engineering.

A: Too many of the military officers don't know how to work with civilians. They're used to giving you an order and having people salute.

Q: Right.

A: Not backtalk, but rather discussion of the decision.

Q: That's a good issue because, when you first went to work for the Engineers, I would imagine that most of the military were pretty good about working with civilians because they'd been trained by a generation that believed, at least the ones I talked to, that you deferred to the senior civilians.

A: Certainly. That's what happened.

Q: You didn't tell them straight-out what to do. You solicited their views.

A: They did their job which was public relations, and putting their uniform on and going up and down the river and showing the flag, and this sort of thing. There were basic decisions that they had to put their imprimatur on. But, of course, on paper they're the boss and could exercise that prerogative if they chose to. But they really deferred to the civilian people around them in most cases. We had some really great division engineers and district engineers.

Q: Do you want to talk about them?

A: No, I don't know them very well.

Q: That's one of the questions I'm going to ask you, eventually.

A: I didn't know the military officers too well.

Tom Hayes

Q: Well, I have some that I knew or I've interviewed. One of them was there at the height of the Omaha District's work on the Missouri was Tom Hayes, Colonel Hayes.

A: Yes.

Q: I spent some time with him when he was out in San Francisco. He had all of those big dams that were going on under him.

A: When he was in the Omaha District, that's correct. First Randall, Gavins Point, and Oahe were all started when he was there.

Q: Do you remember much about him at all?

A: There's a mixed bag of feelings about Colonel Hayes. Tom Hayes was sort of self-contained. He was the boss, all right. He was, Thomas G. Hayes, III, he was.

Q: Right.

A: He may not have been one of the best liked district engineers Omaha had.

Q: That sums it up. Well, I don't have a list of district engineers, unfortunately.

A: Nor division. Some of these names escape me.

Jack Morris

Q: Well, there's certainly one division engineer that you couldn't forget. He was there in the division when you were there and that's Jack Morris.

A: You bet. He was well-liked, but Jack Morris is probably the reason for the change in the character of the Corps of Engineers. I said earlier the Corps of Engineers joined the Army. It was under Jack Morris that happened.

He pushed for the Corps of Engineers to become a major command. That's one of the reasons we went from being the civil works organization of the U.S. Government attached to the Army and reporting to Congress, to being part of the Army and reporting up through the Army chain of command. This is partly the doing of Jack Morris in my view. However, you couldn't help but like him. He was all right.

Chuck Dominy

Q: Yes, he was quite gregarious, I'll say that for him. Still is from what I can see. Later you had Chuck Dominy out there.

A: Oh, yes. He was well respected and well-liked. He was very good. Very fine, in my opinion.

Q: He came from quite an engineering family, too.

A: Yes. Well, his father was Commissioner of Reclamation, although his father was a journalist by background, Floyd Dominy.

Q: Right.

A: He was born in western Nebraska, General Dominy was.

Q: I was just trying to think of some of the people who were out there.

A: Right now, names, maybe senility is catching up with me, I don't know.

Mark Sisinyak

Q: I have trouble from day-to-day myself.

A: General Sisinyak. Did you run into Mark Sisinyak?

Q: Oh, yes, Mark Sisinyak.

A: He was all right. Of course, we were the first command he'd had that was not troops. But he was still okay.

Q: But he was a real genuine guy, I felt.

A: He sure was. You met him then?

Q: Oh, yes. Sure.

A: I liked him a lot. He was okay.

Craig Cannon

Q: He was a good guy, I thought. I'm just trying to remember some of the other ones out there.

A: I don't know what's wrong. I just can't think of the name. Then there was a general who had been one of Eisenhower's aides during the war.

Q: It wasn't Craig Cannon, was it?

A: Craig Cannon. Now, I knew him quite well. We socialized with him.

Q: He was one of the retired generals who has been almost unapproachable. He won't agree to any kind of interview, or he didn't. I think he's still alive.

A: I liked him a lot. My wife was always pulling the faux pas of calling him Colonel Cannon when he was a general at the time. But he was down to earth and friendly and nice.

Q: You always regret when you can't get information on these people or you can't get them to talk to you.

A: Now, Tim Waara, I mentioned Tarmo Waara. Now Craig Cannon was one of Tarmo's junior officers during World War II when Tarmo was with the Engineers in Europe.

Q: Is that right?

A: Yes, he worked for Tim for a short time there. So Tim knew him from way back.

Q: That's interesting, isn't it?

A: Then he caught Eisenhower's eye, that is Craig Cannon did. He joined Eisenhower's staff. As a matter of fact, Eisenhower stood up at his wedding.

Q: Is that right?

A: Once in a while our division engineer was a colonel.

Clyde Selleck

Q: Right.

A: Colonel Selleck is one that we had.

Q: Clyde Selleck.

A: He's one that I personally clashed with more than maybe any of them. We didn't get along.

Bill Ray

Q: Did you ever have much to do with Bill Ray when he was the district engineer in Omaha in the late '70's?

A: I knew him and liked him a lot. He was very popular and he did a good job. He was well respected in both the district and the division.

Q: I did a lot of work with Bill, and I admire him greatly.

A: He went on to have a pretty good career as a general officer.

Q: I remember the day when he was colonel down at Fort Belvoir and I went to see him, because I worked with him when he was down at The Engineer School. It was in the summer of '82 or '83, one or the other. I ran into him outside of headquarters and he looked terribly depressed. And I said, "What's wrong, sir?" He said, "Well, I think you've probably seen the last of Bill Ray." I said, "What do you mean?" He said, "Well, I got passed over for general, so I'm out of here. I've had enough of this." But Joe Bratton convinced him not to retire.

A: To hold on?

Q: To hold on. He got promoted to BG in '84, and he ended up with two-stars.

A: Yes, he did.

Q: So I thought he did pretty well.

A: He did. He was a good one.

Q: Yes, a very, very, nice guy. His wife was a very interesting person, too. I don't know if you ever met her, Bambi?

A: I may have. He was down in the district, of course, when I was up in the division. We met at meetings and social affairs, this sort of thing.

Centers of Expertise

Q: I know at one point in time the Corps was talking about creating these centers of expertise or centers of excellence, and Omaha District was supposed to be a center of expertise for reinforced concrete structures or something like that.

A: Well, Omaha District and MRD had several centers of expertise. There was a center of expertise for corrugated metal roofs. We took the lead on that because the metal roofs were blowing off of some of the hangars at Air Force bases in the Dakotas. We had a center of expertise in transportation, roads and so forth, and, of course, hazardous waste. That grew into a real monster. Another was what they called protective structures, that's designing structures against terrorist attacks. That's a center of expertise in the Omaha District. For years, we were a co-center of expertise for hydroelectric design. Of course, Portland District now has all of that.

Sometimes we sort of informally became a center of expertise. We'd have individuals who took an interest in certain topics. For example, one of our mechanical engineers, Vern Meyer, took an interest in underground heat distribution systems. We worked on that, and we solved a lot of problems they were having at the bases and actually wrote the guidelines for their use throughout the Corps.

Another subject was masonry structures. Ervell Staab, one of our structural engineers, got very deeply into the criteria for the designing of masonry structures. I mean concrete block structures. We were never officially a center of expertise, but OCE depended on Ervell to write the Corps Masonry Manual and sent stuff to Ervell to look over and review. He was a trouble shooter when they had problems.

Of course, I or some of my colleagues were drawn in for river engineering problems all over the country, aside from the Channel Stabilization Committee. Every once in a while we'd be called and we'd go down to the lower Mississippi or some place, and we were recognized as having some capability along that line.

Q: But even those centers of expertise didn't help offset this problem for your engineers who worked for you?

A: No, no. That was mostly a designation on paper. With some exception it didn't generate much work for us. Funds were tight throughout the Corps, so other offices were reluctant to send their own design funds to support a center of expertise.

Q: Yes, that's what I thought.

A: But it's nice to be recognized. Really, expertise, this sort of thing really comes about when an individual gets real interested in a certain subject or problem and gets really turned on by the subject and devotes his energy to doing an extraordinary amount of work in that area. So in a sense it's related to creativity. It depends on an individual's interest and enthusiasm. When you've got an individual who really takes the bit in the teeth and goes ahead with a certain subject, as Ervell Staab did with masonry structures or Vern Meyer did with underground heat distribution systems, for example, then it just sort of becomes a de facto center of expertise. It's not a designation you really pass along willy-nilly to various offices. You've got to find a person who is interested in taking the lead in that area. That's my opinion.

But, of course, the Corps isn't organized that way. But we did a lot of that particularly in the division when I was there. In other words, I gave people full reign to go ahead and do what they were interested in doing, as long as it contributed to accomplishing our mission and other work did not suffer.

Q: In other words, you were loose-handed.

A: Very loose in keeping track of how they did their work. It was my management style, which was appropriate for dealing with experienced professionals. I did keep track of what they were working on and reviewed their progress.

Q: Well, that's the way I found it's best to work, especially when you're dealing with very bright people. You give them their heads and let them go. In fact, I remember interviewing the Chief Engineer of the European Theater, who was Eisenhower's chief engineer, General Cecil R. Moore, who'd been a district engineer out in Portland when they built Bonneville. He told me something I've always remembered and used and kept very close to my style of working with people. He said he always wanted to surround himself with the best and the brightest people. That way he could bask in their reflected glory.

A: That's right.

Q: He said, but a lot of his colleagues could not tolerate anybody. . .

A: Well, they were threatened by that.

Q: Right. They did not want anybody who was smarter than them working for them.

A: That's right.

Q: They didn't want to be shown up. He said, "I always did the reverse." I thought, gosh, this is the right way to do things.

A: That is the right way.

Hazardous Waste, Rocky Mountain Arsenal, and the Superfund

Q: You said hazardous waste became a big expertise center. How did that come about?

A: Well, apparently, the Corps had been talking to EPA. It appeared that the Corps was going to get the mission from EPA to manage the contracts for remediation of the Superfund hazardous waste sites. Omaha District had been doing some work on military hazardous wastes at Rocky Mountain Arsenal out in Denver. I think informally various Corps offices were asked to submit a proposal to be the center to manage the Superfund activities for the Corps.

I had a very capable and experienced environmental engineer, Dick Winecke, and a very capable chief of general engineering, Dick Herse, who was good at reports and putting together proposals. They worked together and prepared a proposal for MRD to become the center of expertise for Superfund. We won the assignment and so it grew. Now they have a huge organization, divided among the division, the districts, and the MRD laboratory.

MRD Laboratory has expanded tremendously. They staffed up with chemists. They spent millions of dollars for equipment for testing hazardous waste materials. Hazardous waste organizations were founded in both districts to provide the project managers for the remedial projects on EPA's Superfund sites around the country. The laboratory was assigned the mission of quality assurance (QA) for chemical testing for Superfund projects.

Q: Now was this part of the Superfund?

A: This is Superfund. That was the mission. Superfund. Remember, the Congress passed that appropriation. Then, by agreement with EPA, the Corps was to manage the remediation, the design and construction for EPA.

After the first year or so, the Corps realized what a big thing this was and so we were asked to pass out some of these projects to other districts who needed work. Today, I believe much of the Superfund work is still the responsibility of the Omaha and Kansas City Districts, the division office, and the MRD laboratory.

Now, when all of this started, I had a sanitary engineering section with two environmental engineers headed by Dick Winecke. So it started under my auspices, but pretty soon became a monster and it broke off and became a branch of its own before I left. Dick Winecke became the chief of a great big burgeoning organization.

Q: Yes. I was up at OCE when that was going on, and I remember them talking about that.

A: Well, there's a lot of it. That's what they did. They talked about it, but it went along for several years there. They spent a lot of money, but at the time I left MRD they hadn't constructed many sites. The reason was the lawyers were in the act trying to get contracts with the owners. They were not quite sure of their criteria, what was hazardous and what wasn't. They got very few sites under contract the first few years. That's changed now. They're moving out. But it started very slowly. A lot of activity, a lot of money being spent, but very little remediation in the first few years.

Q: How much were you doing on the military side in the environmental area?

A: A lot. I mentioned the Rocky Mountain Arsenal.

Q: Right. There was a huge one right there.

A: Oh, yes. The Air Force. The Air Force had hazardous waste sites at bases all over the country, where bad stuff over the years had been buried or dumped on the ground. On the military side, there were a lot of these. Rocky Mountain Arsenal is the big one that I remember because of all of the activity.

Q: Yes, that was a real mess out there.

A: Cleaning up these salts that were the result of the manufacture of nerve gas.

Q: That took a lot of your attention, I imagine.

A: Yes. Up to the time hazardous waste was no longer directly under me.

Q: Oh, that had been moved over.

A: It had been moved out to this new organization.

Q: So they took over both military and civilian?

A: Yes, that's right.

Q: The whole environmental engineering thing.

A: And Dick Winecke took over the responsibility for the thing. I was involved, but I wasn't responsible for all of this.

Q: Just on the technical side.

A: Yes. For a while, these people on paper worked for me. They hadn't created their organization yet so I was involved in a lot of the meetings. But they finally moved it over and became a separate organization. Moved it out of the building.

Q: Completely got away.

A: Yes.

Military Construction

Q: Let me ask you how much different the military engineering side was, military construction, from your civil works experience.

A: Well, it's a big difference because a good share of the military work was done by contract and by A-E under contract and all you're doing is reviewing A-E work. Omaha District did quite a bit of military work in-house, but even so, the majority of military design was contracted out. Kansas City District did a little bit of military in-house, but by far, most of their work was A-E work. So it was just a different ball game entirely. Civil works, at that time, was all in-house design.

Q: It still was?

A: Yes.

Q: That's changed now, I imagine.

A: That's changing. They're supposed to have a certain percent of it, 30 percent or whatever it is, is supposed to be by A-E. But you can't review anybody's work or plan effective projects unless you do some of the design yourself. You have no basis for evaluating the design, unless you've done some yourself. That's my view. We always tried to maintain as much in-house design as they would let us.

Q: What aspects of the in-house design did you have the most trouble with?

A: In military?

Q: Either one, military or civil.

Corrugated Metal Roofing

A: Oh, there would be certain topics that were hot. Like for a while there, I mentioned, these corrugated metal roofs were blowing off of the big new hangars up in Minot and Grand Forks [North Dakota], and Ellsworth [South Dakota]. So there was a big push for several years trying to find out why this was happening and to write new design criteria and guide specifications for the corrugated metal roofing materials. So we had quite a research effort there. The same engineer I mentioned, Ervell Staab, was involved with that very heavily. I think we made quite a contribution to solving the corrugated metal roof problem. Ervell Staab is a good one to talk to. He's still there at MRD. That's one thing–it was hot for the military.

Underground Heat Distribution Systems

You'd get these guide specs for building certain features, and sometimes they have problems. Underground heat distribution systems at the military bases-- we had a lot of trouble with the installation failing and losing heat. We had quite an exercise where we pushed for revising the design of these things throughout the country. We took the lead in that.

Q: Are those guide specs the same thing as the standardized designs?

A: Yes, standardized designs. Do you know what these systems are?

Q: Which one, underground heat?

A: Yes.

Q: Well, they're like the old steam plants, aren't they?

A: Yes, and they've got these buried conduits that convey steam or hot water to the outlying buildings.

Q: Right.

A: They are insulated to minimize heat loss. There's just no way you could bury something in wet ground for any period of time without having a leak someplace in the outer casing that allows the insulation to be soaked. Soaked insulation no longer is a heat insulator, so they developed high heat losses in the steam or hot water pipe that was inside. We were putting the insulated conduits in open trenches with lids on them. The trenches were drained so that water would not contact the insulated pipe but somebody in the military part of the Chief's office had a vested interested in these buried, encased heat liners. It was a patented method, wrapping these pipes, encasing them. It was a hard sell to get them to come off of these buried heat distribution conduits.

Q: Now, were they up in the Air Force bases like Minot and Grand Forks?

A: Yes, they were. They were all over the country.

Q: They had to be a real problem in an area where you have freezing and thawing like that.

A: Oh, yes, they were a problem. And, you know, they're insulated and they have a casing on the outside, a wrapping.

Q: Right.

A: Once the insulation gets wet, it isn't an insulator anymore. So these casings would leak, and then there'd be tremendous heat losses. They wouldn't be doing their job of heat distribution. For this reason, we started using the concrete trenches with the pipe suspended inside. They seemed to work very well, but abandoning the buried conduit for wet areas was a tough sell.

Another thing, there were a lot of problems with concrete block masonry walls cracking. We found this could be avoided with the proper details in the guide specs for how you attach the roofs and how you reinforce them, and so forth. We got into that, and eventually, Ervell Staab wrote a new masonry design manual for the Corps.

The Air Force as a Customer

Q: How was the Air Force as a customer? Did you have a lot of difficulty with them?

A: No. I think our military project management people had a very good relationship with the Air Force. I think, all and all, we had a good relationship with them.

Q: There are a lot of engineers we've talked to that found the Air Force to be very difficult to deal with.

A: Well, they're difficult to deal with if you don't produce the work on schedule for them. I don't think they were difficult to deal with. We made a lot of our own problems. If we were behind schedule on something or we had a design glitch or something, it was our own fault. All and all, they were good to deal with. That's my opinion.

Q: Was it that most of the Army facilities weren't very demanding, I don't imagine, for instance, Fort Riley.

A: Well, you see the Air Force is organized differently from the Army. In the Air Force, the facilities belong to the facility command. The Air Force units are tenants in these buildings, so we deal with the regional civil engineer office or the AFRCE [Air Force Regional Civil Engineer] of the facility command. That's an engineering organization with capable people. But in the Army, the facility belongs to the commander, so you deal with the commander of the facility you are constructing.

Q: Oh, yes.

A: Yes. It's a different setup. Of course, a commander is a commander. He can get very arbitrary. "I want blue paint here and green paint there. And I want this and I want that." He can just dictate what he wants.

Q: Did you get involved at all with the Air Forces' ballistic missile facilities?

A: No. I was not on any of the silos.

Q: Okay.

A: See, I didn't get involved in military work at all until about 1978.

Q: Yes, most of that had already been done.

A: I think engineering dealt with the design of both military and civil works.

Q: I think most of the Minuteman III stuff was already finished.

A: Oh, they were being torn down by then.

Q: They were taking them out?

A: Yes.

Q: The big facility, the Safeguard Facility up in Grand Forks, was already on the way out by then?

A: Yes.

Q: After all of that work.

A: NORAD [North American Air Defense Command], the big installation at NORAD, was in its last phase, I think.

Q: It's still there, but all of the work had been done by that time.

A: Yes. It was an interesting education. You never get old enough to get an education.

Army Military Construction Work

Q: How much involved were you with the Army down at Fort Leonard Wood?

A: I was involved only to the extent that I went down on a couple of trips to inspect some buildings we had designed and were constructing down there.

Q: Because that's where they built that whole new Engineer Center.

A: Yes.

Q: So really, at your level, you only got involved if there were significant problems?

A: Yes. There was one building I was involved with. It was the VOQ or visiting officers' quarters. We tried a new method of procurement. We tried a design-construct contract, a contract for someone to design it and construct it and turn it over to us when it was completed. Anyway, we spent a lot of time on that particular procurement method because it looked like it was very promising. That was at Fort Leonard Wood.

Q: I know. There's always something new, isn't there?

A: Yes.

Experience in Consulting Work

Q: I see that you had an active consulting career both while you were working at MRD and also in retirement. Could you discuss your consulting work?

A: Well, I did some consulting when I was in the Corps.

Taiwan

Q: I noticed you did that. Some with Taiwan.

A: You have my resumé? Okay. Well, maybe you can get a rundown from that. Let's see. I was involved in Bangladesh. I was consulting on my own. I was still with the Corps, but took leave to do that--went to Bangladesh with Harza Engineering Company. AID [Agency for International Development] borrowed me a couple of times. I was in Taiwan for six weeks in 1964, and in Ecuador for two weeks in 1983.

Q: In '73, you were in Taiwan again.

A: In '73, I was there again for six weeks. This time the Taiwan Government borrowed me from the Corps and reimbursed the Corps for my salary and expenses. This had to do with flood control for the Tan Shui River which runs right through the middle of Taipei. There was a huge local controversy on which flood control plan to adopt because it depended on who had to give up the land, so I came in as the outside expert. I had to report on the alternatives and make a recommendation. That was an interesting process.

Q: Now, how different did they view flood control there or was it the same perspective that we have here?

A: I think they had a similar perspective except that they were much more willing to design these projects on the bases of the frequency. They look at a one percent flood, or something like that. They were willing to take a chance on that. But actually there are two chances out of three that a percent flood would be exceeded during a 100-year period. These aren't very good odds for a major city. One of my tasks was to try to convince them to use the Corps of Engineers standards in terms of the height of structures that are going through the middle of the cities where a failure might kill hundreds of people.

Q: Well, that's one of the things that Jake Douma emphasized that over the years a lot of the Corps of Engineers design criteria and standards have been adopted as fairly standard worldwide by many countries.

A: That's right. I think I imposed those on the projects there in Taiwan.

Ecuador

Of course, I also went to Ecuador with the AID office there. You've probably got that on your list, haven't you?

Q: Yes.

A: It was in 1983. The El Niño floods had destroyed much of Ecuador's infrastructure. I was involved in a report on restoring water supply and flood protection in the Guayas River Basin.

Bangladesh

Q: Well, Bangladesh is interesting because of the real problems on those huge rivers and the problems with the typhoons coming in off of the Bay of Bengal.

A: That's right.

Q: Is that a solvable problem?

A: I don't know. You know, those two rivers come together.

Q: The Ganges and the Brahmaputra?

A: They form the Padma which flows on out to the Bay of Bengal, and either river is about the size of the Mississippi. If a typhoon blows to the north out of the Bay of Bengal, you get a wind surge of several meters. Maybe 80 percent of country of Bangladesh is the delta of this river system, just like the delta area of the Mississippi River, analogous to that. When you get one of these wind tides simultaneous with floods on the two rivers, you might have half or two-thirds of the country under water.

Q: Well, that's what Frank Snyder said. He went over and did some consulting on it, and he said the cost to have built anything to protect the country from the huge killer typhoons that come in there would have been almost impossible.

A: Yes, they wanted to know about a plan to build levees along both sides of the Brahmaputra. But you only have to go into that poor country and see how they take care of their infrastructure to know that if you built levees along both sides of the Brahmaputra, you'd be building some death traps. They'd never be able to maintain them, and just the bank protection alone would be a gigantic task. The river shifts from side to side very actively with each flood, and it's about 10-miles wide.

Q: Yes. Wouldn't that present a problem with their whole agricultural system? You'd have to put gates in there for the tides?

A: And so you'd be building death traps. The water isn't very deep when it does flood. You know, there are sandbars out in the middle of the Brahmaputra and there are villages on them. When you fly over these sand bars you see that the houses are in line so that the first house breaks the current, creates sort of a bow wave and the other houses behind it are in the shadow of this first house. You can just see this in the configuration of the sandbars, and the people just stay there. They may be up to their knees or up to their hips in water for weeks on end, but they stay there.

Q: Well, they've got nowhere else to go, do they?

A: Or if it's an extraordinary flood that gets above their heads, they drown. That's particularly the case down in the Samaradan, down in the areas along the Bay of Bengal, where they have some polders down there that are leveed and where these wind tides have sometimes gone over the tops of these levees, drown them, maybe a couple hundred thousand people, like rats in a trap. It's sad when you take a look at it. Anyway, that was an interesting time.

Pakistan

Q: It looks like the biggest amount of time you spent has been in Pakistan for Harza.

A: I went with Harza Engineering in 1989.

Q: And Louis Berger?

A: And then with Louis Berger for a few months at a time, twice.

Q: In Pakistan, it's flood protection work on the Indus River Basin.

A: Right. That is what I was working on when I was with Harza.

Q: That's somewhat similar to the problem over in Bangladesh, isn't it?

A: Well, no. The situation isn't as hopeless and is entirely different.

Q: But I mean it's driven by rains and large rivers.

A: Oh, yes, the monsoons. There's a snow melt, but then in the monsoon season, you get big monsoon floods that come down the Indus River, and it's a big, wide, flood plain, quite analogous to the Mississippi. The river is very unstable and active and it's very difficult to protect the banks. The river bed consists of highly erodible very fine sand. It's a huge river with maybe three, four, five miles across.

But there's a very well-developed irrigation system there that has created a very rich agricultural economy. In fact, it's like the Imperial Valley in California. The British constructed these big canal systems. You can go to the edge of the irrigated flood plain and look one way and you can see desert. Then when you look the other way you see green crop lands, all kinds of crops, anything you want to grow from corn to rice, to fruit trees, you name it. Pakistan really doesn't have a food problem.

Q: How much time did you actually spend in Pakistan itself?

A: I spent the whole time in Pakistan.

Q: You were eighteen months in Pakistan.

A: I lived in the city of Lahore.

Q: Were up in the mountains?

A: No, Lahore is in the Punjab area. It's south of Islamabad and south of the mountains. It's about the same latitude as Delhi over in India. It's on one of the tributaries to the Indus.

Q: You were working for what, one of the ministries there?

A: I was working for the ministry for flood control on the Indus River. I've forgotten the formal name.

Q: Have a lot of what you worked on been built or was it just the planning part?

A: We were supposed to plan and build things. Of course, in a year and a half, we only got some works under contract.

Q: So they're in the process of being finished?

A: We were supposed to come up with flood warning systems. I am not sure what progress was made after I left.

Q: So there are a lot of the same things that you worked on on the Missouri River?

A: Of course, the bureaucracy there in Pakistan, they were interested in absorbing the money that the Asian Bank was providing, but they weren't too anxious to adopt the design measures we were recommending. As soon as we left, I'm sure they just went their own way. It's a little frustrating.

Q: I think this is probably the case of a lot of these consulting things supported by the Ex-Im (Export-Import) Bank and things like that.

A: Right.

Q: Then you did work for Louis Berger there, too.

A: Yes. That was down in Karachi, Pakistan, in 1992. We made then a study of the possibility of barge navigation on the big canals adjacent to the Indus River system.

Indonesia

Well, then in 1994, my wife and I spent six weeks in Indonesia. We lived in Jakarta while I worked for Louis Berger. We were studying how to improve the navigation on three rivers in Sumatra, and we lived in Jakarta on the Island of Java although the project was over in Sumatra.

Q: So that's the last consulting you've done, then?

A: That's really the last I've done. Oh, there's a couple of legal cases I've been involved with.

Expert Testimony

Q: Expert testimony kind of thing?

A: Yes. The California Grape Growers were suing the SP [Southern Pacific] Railroad because in 1993 they delivered their grapes too late for the wine making in Toronto. I was hired to give testimony on the flood conditions along the route from California to Toronto in 1993 that might or might not have affected the railroad.

Q: Like 10 feet of water over their lines or something like that?

A: Yes.

Q: You wonder why they'd even bother, wouldn't you?

A: Yes. I don't know how the trial came out. I'm going to have to call and find out.

Conclusion

Q: Do you have anything in summation or conclusion you want to say?

A: No, I think we've said a lot here.

Q: I appreciate your great consideration and patience with this. It takes a while, and it can be a little difficult sometimes. But I enjoyed it and learned a lot, and I think the people at the Corps will be very interested in it when they see it.

A: I certainly enjoyed talking with you.

Q: I enjoyed talking with you, too.